PETROLEUM, ASPHALT AND NATURAL GAS

BULLETIN No. 14

KANSAS CITY TESTING LABORATORY

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AND
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KANSAS CITY, MISSOURI

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PREFACE

This bulletin is intended to be a compact handbook of petroleum, asphalt and natural gas, containing statistical and technical information, data and tables.

The matter presented is with considerable elimination that gathered into a petroleum laboratory and refinery engineering note book.

Statements as to the origin of information are not made throughout the bulletin, but the author wishes to acknowledge the following as the chief sources of the matter set forth.

SOURCES OF MATTER IN THIS BULLETIN.

Research and Commercial Departments of the Kansas City Testing Laboratory.

United States Patents.

U. S. Bureau of Standards Publications.

U. S. Bureau of Mines Publications.

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1013 Grand Avenue,
Kansas City, Missouri.

May 1, 1918.

Value of Petroleum as a Mineral Product

The value of refined petroleum in the United States in 1917 exceeded the value of any of the metals except iron, which it approximately equaled, and was greater than the combined value of gold, silver, copper, lead and zinc.

The only natural mined product exceeding it in value is coal. The comparison of the value of refined products of petroleum and of metals is as follows:

VALUE OF MARKETED MINERAL PRODUCTS IN UNITED STATES IN 1917.

	Quantity	Value	% of World
Refined Petroleum	347,000,000 bbls.	$1,250,000,000	65
Pig Iron ($41 per long ton).....	38,367,853 tons	1,573,000,000	30
Copper ($0.2718 per pound).....	1,888,395,945 lbs.	513,100,000	60
Zinc ($0.08901 per pound)......	685,436 tons	122,000,000	30
Lead ($0.06858 per lb.).........	580,464 tons	79,500,000	35
Silver ($0.81417 per oz.)........	74,244,500 ozs.	60,460,000	50
Gold ($20.67 per oz.)..........	4,200,000 ozs.	84,450,000	20

The value of crude petroleum at the wells was approximately $700,000,000 in 1917. The value of the production from the Mid-Continent field, consisting of Kansas and Oklahoma, in 1917 was approximately $250,000,000. This alone is greater than the yearly value of all the copper ore, gold and silver ore or lead and zinc ore of the United States. The amount of refined products from petroleum during 1917 was approximately as follows:

Gasoline and Naphtha	64,000,000	barrels*
Kerosene	40,000,000	"
Lubricating oils	17,000,000	"
Paraffin waxes	1,400,000	"
Fuel and Gas oils	160,000,000	"
Asphalt and Road oils	6,000,000	"
Greases	300,000	"
Other uses and losses	15,000,000	"

*42 gallons to the barrel.

The Demand For Petroleum Products

The demand for petroleum is greatest as a fuel, this use representing something like 55% of the total consumption. Of this 160 million barrels, more than 100 million could and should be replaced by coal. The United States Navy consumes at the rate of 6 million barrels per year in peace time and about 18 million per year in war time, an amount which could not be substituted, and there are some industries which require the peculiar properties of liquid or low sulphur fuel. The price of coal then must, to a very large extent, govern the prices of petroleum products. The most important and the most interesting product of petroleum is gasoline, because the demand for it has greatly transformed the refining industry. The governing factor in this change has been the gasoline automobile. This rapid growth of automobiles and gasoline production is set forth as follows:

Year	Automobiles	Gasoline, bbls.	% in Crude Oil
1905	85,000	7,900,000	5.91%
1910	400,000	14,750,000	7.04
1914	1,253,000	34,900,000	13.14
1916	2,225,000	49,020,000	19.85
1917	3,250,000	64,290,000	21.15

It appears that either the increase in the automobiles must diminish or the increase in per cent of gasoline obtained from crude must go on. The increase of gasoline from crude in the past year has been due most largely to cracked gasoline, and this must be the future source and at the expense of fuel oil and kerosene.

The demand on U. S. refineries for gasoline and naphtha in 1918 has been estimated as follows:

Pleasure automobiles	20	million bbls.
Export	15	" "
Commercial auto service	12	" "
U. S. Army	8	" "
Stationary gasoline engines	8	" "
Other uses	10	" "

Wax and lubricants are the most valuable products of petroleum, demanding the most careful selection of the grade of petroleum for

the best products and requiring the most elaborate refining equipment.

An additional source of fuel oil, lubricating oils, wax and kerosene is to be found in the oils capable of being distilled from oil shales and cannel coals, of which there are enormous quantities. This will allow the extensive use of the paraffin petroleum hydrocarbons for production of gasoline, into which they may be converted with much less waste than in the case of shale oils. The following outlines some of the uses of petroleum products:

Gasoline and Naphtha—Gas lighting, laboratory solvents, cleansing, gasoline stoves, automobiles, extraction of seed oils, metal polishes, gasoline engines, paint vehicles, asphalt paint and road binder solvent.

Kerosene and Illuminating Oils—Lamps, distillate engines, signal lights, gas washing and absorbents, portable stoves.

Gas Oil—Pintsch gas, Blaugas, town gas, straw oil, house heating, cracking, anti-corrosives.

Heavy Distillates—Lubricants, spindle oil, auto oil, machine oil, engine oil, cylinder oil, greases, vaseline, wax, medicinal oil, waterproofing for fabrics, candles, soap filler, paints, polishes.

Liquid Residua—Steam production, house heating, concrete waterproofing, road and macadam oils, dust prevention, cracking.

Semisolid Residua—Asphalt pavement, waterproofing, brick filler, roofing, rubber filler or substitute.

Crude Oils—Diesel engines, dust prevention, waterproofing.

WORLD'S PRODUCTION OF PETROLEUM IN 1916.

Country	Barrels of 42 gallons	Metric tons	Percentage total
United States	300,767,158	40,102,288	65.29
Russia	72,801,110	9,333,387	15.81
Mexico	39,817,402	5,308,987	8.64
Dutch East Indies	13,174,399	1,820,247	2.86
Roumania	10,298,208	1.432,296	2.24
Indian	8,228,571	1,097,143	1.79
Galicia	6,461,706	898,670	1.40
Japan and Formosa	2,997,178	399,624	0.65
Peru	2,550,645	340,086	0.55
Trinidad	1,000,000	139,082	0.22
Germany	995,764	140,000	0.22
Argentina	870,000	116,000	0.19
Egypt	411,000	54,800	0.09
Canada	198,123	26,416	0.04
Italy	43,143	6,000	0.01
Other Countries	25,000	3,333	0.01
	460,639,407	61,818,359	100.00

PETROLEUM PRODUCTION BY STATES IN 1915, 1916, 1917.

State	1915	1916	1917
Oklahoma	97,915,243	111,000,000	97,600,000
California	86,591,535	92,000,000	97,000,000
Texas	17,467,598	26,000,000	30,000,000
Illinois	19,041,695	16,500,000	11,000,000
Louisiana	18,191,539	17,000,000	15,000,000
West Virginia	9,264,798	8,500,000	8,000,000
Pennsylvania	7,838,705	8,000,000	8,000,000
Ohio	7,825,325	7,400,000	7,000,000
Kansas	2,823,487	11,500,000	38,000,000
Wyoming-Montana	4,245,525	6,300,000	10,000,000
Kentucky	437,274	1,200,000	4,000,000
Indiana	875,758	1,000,000	1,000,000
New York	887,778	900,000	900,000
Colorado	208,475	190,000	200,000
Other States	14,262	10,000	10,000
	281,104,104	307,500,000	327,610,000

PRODUCTION OF CRUDE OIL IN 1914, 1915, 1916 & 1917 BY FIELDS.

Fields	1914 Bbls.	1915 Bbls.	1916 Bbls.	1917 Bbls.
Eastern Fields	22,436,771	20,333,483	20,724,836	19,860,169
Ohio-Indiana	4,603,275	3,979,467	2,606,831	3,809,170
Illinois	19,330,245	15,588,493	16,349,274	11,520,108
Kentucky-Tennessee	516,110	479,366	1,244,752	4,015,639
Mid-Continent	101,002,263	121,988,915	122,671,767	135,632,794
Gulf Coast	11,980,000	20,355,259	21,848,115	25,237,637
Texas Panhandle	8,513,367	5,591,422	8,852,865	10,685,623
Northern Louisiana	12,507,436	14,730,713	11,848,301	8,648,025
California	102,871,907	89,725,776	91,916,019	97,267,832
Wyoming	4,360,000	5,164,737	8,030,000	10,000,000
Other States	180,000	200,000	205,000	210,000
Total	287,119,667	298,137,631	306,297,760	326,895,000

MONTHLY PRODUCTION IN 3 CHIEF MID-CONTINENT DISTRICTS IN 1916 AND 1917.

1916.

Month	Cushing	Healdton	Kansas (Chiefly Butler Co.)
January	2,444,264	2,153,189	310,999
February	2,859,996	1,448,201	383,689
March	3,113,892	1,495,400	485,349
April	2,936,520	1,460,144	631,692
May	3,539,143	1,396,262	884,214
June	4,118,931	1,445,621	868,482
July	4,100,296	1,352,002	1,066,562
August	4,102,779	1,343,211	1,193,535
September	3,238,434	1,526,988	1,457,568
October	2,961,976	1,762,243	2,475,567
November	2,532,789	1,629,120	2,146,230
December	2,328,172	1,526,283	2,047,916
Totals	38,277,192	18,538,664	13,961,803

1917.

Month	Cushing	Healdton	Kansas (Chiefly Butler Co.)
January	2,323,593	1,625,041	2,024,997
February	2,233,061	1,721,620	1,819,189
March	2,654,709	2,216,199	2,379,290
April	1,908,559	1,785,102	1,990,825
May	1,899,586	1,879,263	2,015,800
June	2,168,452	2,425,429	2,991,786
July	1,709,987	2,017,890	2,553,463
August	1,947,291	2,474,132	3,777,935
September	1,599,031	1,849,228	3,617,581
October	1,581,511	1,779,658	3,727,185
November	1,637,635	2,059,629	4,783,790
December	1,444,903	1,618,232	3,335,699
Totals	23,108,318	23,451,423	35,017,540

TOTAL CONSUMPTION OF OIL IN 1917 IN UNITED STATES.

	Barrels
Amount of oil taken from storage in U. S. in 1917	20,000,000
Amount of oil imported from Mexico in 1917	35,000,000
Amount of oil produced in U. S. in 1917	327,000,000
Total	382,000,000


IMPORTANT PETROLEUM FIELDS
Eastern or Appalachian
Ohio-Indiana
Illinois
Kentucky
N. La Caddo
Gulf Coastal
Texas Pan-Handle
Mid-Continent Field
Wyoming Field
California Field

PETROLEUM MARKETED IN THE UNITED

Year.	Pennsylvania and New York.	Ohio.	West Virginia.	California.	Kentucky and Tennessee.	Colorado.	Indiana.	Illinois.
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
1859	2,000	....	....	....	....	....	....	....
1860	500,000	....	....	....	....	....	....	....
1861	2,113,609	....	....	....	....	....	....	....
1862	3,056,690	....	....	....	....	....	....	....
1863	2,611,309	....	....	....	....	....	....	....
1864	2,116,109	....	....	....	....	....	....	....
1865	2,497,700	....	....	....	....	....	....	....
1866	3,597,700	....	....	....	....	....	....	....
1867	3,347,300	....	....	....	....	....	....	....
1868	3,646,117	....	....	....	....	....	....	....
1869	4,215,000	....	....	....	....	....	....	....
1870	5,260,745	....	....	....	....	....	....	....
1871	5,205,234	....	....	....	....	....	....	....
1872	6,293,194	....	....	....	....	....	....	....
1873	9,893,786	....	....	....	....	....	....	....
1874	10,926,945	....	....	....	....	....	....	....
1875	8,787,514	....	....	....	....	....	....	....
1876	8,968,906	31,763	120,000	12,000	....	....	....	....
1877	13,135,475	29,888	172,000	13,000	....	....	....	....
1878	15,163,462	38,179	180,000	15,227	....	....	....	....
1879	19,685,176	29,112	180,000	19,858	....	....	....	....
1880	26,027,631	38,940	179,000	40,552	....	....	....	....
1881	27,376,509	33,867	151,000	99,862	....	....	....	....
1882	30,053,500	39,761	128,000	128,636	....	....	....	....
1883	23,128,389	47,632	126,000	142,857	4,755	....	....	....
1884	23,772,209	90,081	90,000	262,000	4,148	....	....	....
1885	20,776,041	661,580	91,000	325,000	5,164	....	....	....
1886	25,798,000	1,782,970	102,000	377,145	4,726	....	....	....
1887	22,356,193	5,022,632	145,000	678,572	4,791	76,295	....	....
1888	16,488,668	10,010,868	119,448	690,333	5,096	297,612	....	....
1889	21,487,435	12,471,466	544,113	303,220	5,400	316,476	33,375	1,40
1890	28,458,208	16,124,656	492,578	307,360	6,000	368,842	63,496	90
1891	33,009,236	17,740,301	2,406,218	323,600	9,000	665,482	136,634	67
1892	28,422,377	16,362,921	3,810,086	385,049	6,500	824,000	698,068	521
1893	20,314,513	16,249,769	8,445,412	470,179	3,000	594,390	2,335,293	400
1894	19,019,990	16,792,154	8,577,624	705,969	1,500	515,746	3,688,666	300
1895	19,144,390	19,545,233	8,120,125	1,208,482	1,500	438,232	4,386,132	200
1896	20,584,421	23,941,169	10,019,770	1,252,777	1,680	361,450	4,680,732	250
1897	19,262,066	21,560,515	13,090,045	1,903,411	322	384,934	4,122,356	500
1898	15,948,464	18,738,708	13,615,101	2,257,207	5,568	444,383	3,730,907	360
1899	14,374,512	21,142,108	13,910,630	2,642,095	18,280	390,278	3,848,182	360
1900	14,559,127	22,362,730	16,195,675	4,324,484	62,259	317,385	4,874,392	200
1901	13,831,996	21,648,083	14,177,126	8,786,330	137,259	460,520	5,757,086	250
1902	13,183,610	21,014,231	13,513,345	13,984,268	185,331	396,901	7,480,896	200
1903	12,518,134	20,480,286	12,899,395	24,382,472	554,286	483,925	9,186,411	....
1904	12,239,026	18,876,631	12,644,686	29,649,434	998,284	501,763	11,339,124	....
1905	11,554,777	16,346,660	11,578,110	33,427,473	1,217,337	376,238	10,964,247	181,084
1906	11,500,410	14,787,763	10,120,935	33,098,598	1,213,548	327,582	7,673,477	4,397,050
1907	11,211,606	12,207,448	9,095,296	39,748,375	820,844	331,851	5,128,037	24,281,973
1908	10,584,453	10,858,797	9,523,176	44,854,737	f727,767	379,653	3,283,629	33,686,238
1909	10,434,300	10,632,793	10,745,092	55,471,601	f639,016	310,861	2,296,086	30,898,339
1910	9,848,500	9,916,370	11,753,071	73,010,560	f468,774	239,794	2,159,725	33,143,362
1911	9,200,673	8,817,112	9,795,464	81,134,391	f472,458	226,926	1,695,289	31,317,038
1912	8,712,076	a8,969,007	12,128,962	g87,272,593	f484,368	206,052	970,009	28,601,308
1913	8,865,493	8,781,468	11,567,299	97,788,525	f524,568	188,799	956,095	23,893,899
1914	9,109,309	8,536,352	9,680,033	99,775,327	502,441	222,773	1,335,456	21,919,749
1915	8,726,483	7,825,326	9,264,798	86,591,535	f437,274	208,475	875,758	19,041,695
	762,906,696	440,587,330	269,497,613	827,865,091	9,533,214	10,857,618	103,699,558	251,368,311

a Includes the production of Michigan.
b Includes the production of Oklahoma.
c Included with Kansas.
d Estimated.
e Includes production of Utah.

STATES, 1859-1915 (in 42-Gal. Bbls.)

Kansas.	Texas.	Missouri.	Oklahoma.	Wyoming.	Louisiana.	United States.	Total value.	Year.
Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.		
....	....	....	....	....	....	2,000	$32,000	1859
....	....	....	....	....	....	500,000	4,800,000	1860
....	....	....	....	....	....	2,113,609	1,035,668	1861
....	....	....	....	....	....	3,056,690	3,209,525	1862
....	....	....	....	....	....	2,611,309	8,225,663	1863
....	....	....	....	....	....	2,116,109	20,896,576	1864
....	....	....	....	....	....	2,497,700	16,459,853	1865
....	....	....	....	....	....	3,597,700	13,455,398	1866
....	....	....	....	....	....	3,347,300	8,066,993	1867
....	....	....	....	....	....	3,646,117	13,217,174	1868
....	....	....	....	....	....	4,215,000	23,730,450	1869
....	....	....	....	....	....	5,260,745	20,503,754	1870
....	....	....	....	....	....	5,205,234	22,591,180	1871
....	....	....	....	....	....	6,293,194	21,440,503	1872
....	....	....	....	....	....	9,893,786	18,100,464	1873
....	....	....	....	....	....	10,926,945	12,647,527	1874
....	....	....	....	....	....	8,787,514	7,368,133	1875
....	....	....	....	....	....	9,132,669	22,982,822	1876
....	....	....	....	....	....	13,350,363	31,788,566	1877
....	....	....	....	....	....	15,396,868	18,044,520	1878
....	....	....	....	....	....	19,914,146	17,210,708	1879
....	....	....	....	....	....	26,286,123	24,600,638	1880
....	....	....	....	....	....	27,661,238	25,448,339	1881
....	....	....	....	....	....	30,349,897	23,631,165	1882
....	....	....	....	....	....	23,449,633	25,790,252	1883
....	....	....	....	....	....	24,218,438	20,595,966	1884
....	....	....	....	....	....	21,858,785	19,198,243	1885
....	....	....	....	....	....	28,064,841	19,996,313	1886
....	....	....	....	....	....	28,283,483	18,877,094	1887
....	....	....	....	....	....	27,612,025	17,947,620	1888
500	48	20	....	....	....	35,163,513	26,963,340	1889
1,200	54	278	....	....	....	45,823,572	35,365,105	1890
1,400	54	25	30	....	....	54,292,655	30,526,553	1891
5,000	45	10	80	....	....	50,514,657	25,906,463	1892
18,000	50	50	10	....	....	48,431,066	28,950,326	1893
40,000	60	8	130	2,369	....	49,344,516	35,522,095	1894
44,430	50	10	37	3,455	....	52,892,276	57,632,296	1895
113,571	1,450	43	170	2,878	....	60,960,361	58,518,709	1896
81,098	65,975	19	625	3,650	....	60,475,516	40,874,072	1897
71,980	546,070	10	....	5,475	....	55,364,233	44,193,359	1898
69,700	669,013	132	....	5,560	....	57,070,850	64,603,904	1899
74,714	836,039	a1,602	6,472	5,450	....	63,620,529	75,989,313	1900
179,151	4,393,658	a2,335	10,000	5,400	....	69,389,194	66,417,335	1901
331,749	18,083,658	a757	37,100	6,253	548,617	88,766,916	71,178,910	1902
932,214	17,955,572	a3,000	138,911	8,960	917,771	100,461,337	94,694,050	1903
4,250,779	22,241,413	a2,572	1,366,748	11,542	2,958,958	117,080,960	101,175,455	1904
b12,013,495	28,136,189	a3,100	(c)	8,454	8,910,416	134,717,580	84,157,399	1905
b21,718,648	12,567,897	a3,500	(c)	d7,000	9,077,528	126,493,936	92,444,735	1906
2,409,521	12,322,696	a4,000	43,524,128	e9,339	5,000,221	166,095,335	120,106,749	1907
1,801,781	11,206,464	a15,246	45,798,765	e17,775	5,788,874	178,527,355	129,079,184	1908
1,263,764	9,534,467	a5,750	47,859,218	e20,056	3,059,531	183,170,874	128,328,487	1909
1,128,669	8,899,266	a3,615	52,028,718	e115,430	6,841,395	209,557,248	127,899,688	1910
1,278,819	9,526,474	a7,995	56,069,637	e186,695	10,720,420	220,449,391	134,044,752	1911
1,592,796	11,735,057	(h)	51,427,071	1,572,306	9,263,439	222,935,044	164,213,247	1912
2,375,029	15,009,478	i10,843	63,579,384	2,406,522	12,498,828	248,446,230	237,121,388	1913
3,103,585	20,068,184	j7,792	73,631,724	3,560,375	14,309,435	265,762,535	214,125,215	1914
2,823,487	24,942,701	j14,265	97,915,243	4,245,525	18,191,539	281,104,104	179,462,890	1915
57,725,079	228,742,082	86,977	533,394,201	12,210,469	108,086,972	3,616,561,244	2,971,388,126	

f No production in Tennessee recorded.
g Includes small production of Alaska.
h No production in Missouri; Michigan included in Ohio.
i Includes production of Alaska, Michigan, and New Mexico.
j Includes production of Alaska and Michigan.

Geological Occurrence of Petroleum and Natural Gas

The following summarizes the geologic conditions under which petroleum and natural gas occur:

1. They occur in sedimentary rocks of all geologic ages from Silurian upward. The most productive areas are the Paleozoic in North America and the Miocene in Russia.

2. There is no relation of the occurrence of petroleum to volcanic or igneous action. There seems to be some relation, particularly in the carboniferous and the Mississippian, to the deposits of coal.

3. The most productive areas for oil in great quantity are where the strata are comparatively undisturbed. Oil frequently occurs where the strata are highly contorted and disturbed but in less abundance, and gas is usually absent.

4. In comparatively undisturbed as well as in disturbed areas a folded or dome structure often favors the accumulation of oil and gas in the domes or anticlines.

5. Important requisites for a productive oil or gas field are an impervious cap rock or cover and a porous reservoir.

6. Salt water almost universally accompanies oil and gas in the same sand.

In the United States, oil is found most abundantly in the Tertiary rocks in California and the Gulf Coast, in upper cretaceous in Wyoming, in carboniferous locally known as the Cherokee Shales in the Mid-Continent field, in the sub-carboniferous or Mississippian and the Upper Devonian in the Appalachian field and in Illinois, and in the Ordovician in Ohio and Indiana. The oils from the Tertiary are heavy and of low grade, those from the cretaceous, carboniferous, and sub-carboniferous are light, high grade oils. The Mississippian in the Mid-Continent field is not supposed to carry any oil and nothing is known of it or deeper strata in this territory. It is assumed that the deeper strata have vanished west of the Ozark uplift.

The accumulation of petroleum occurs in a pervious reservoir which usually consists of a loose sand though it may be a coarse gravel or a disrupted shale or limestone. It is merely necessary that the rock should contain a considerable amount of voids. The ordinary sand will have from 15% to 35% of voids and the amount of oil contained and the ease with which it is discharged into a well vary greatly. As a general rule, one gallon of oil may be obtained from one cubic foot of oil sand. It is probable that never over 75% of oil surrounding a well is discharged into the well even with the lighter oils, and the per cent abstracted is much lower with the heavier and more viscous oils. Porous sand or gravel and heavy gas pressure are conducive to rapid expulsion of oil. Fine sand and low pressure give steadily producing wells of great longevity. The ultimate production of a well would be

determined by the depth and extent of the sand, the physical character of the sand, the physical character of the oil and the pressure.

In every sand, there occur together, gas, oil and salt water. The gas invariably occupies the uppermost portion of the sand, the salt water, the bottom, with the oil intermediate. The sand usually lies at the same angle or dip as the stratum in which it is contained, so that this fact forms the basis to a great extent of the geologist's work. It is to be noted that the surface topography has no relation to the probable location of oil or the dip or "strike" of the formation beneath the surface. Asphalt exposures are not good indications of oil in the immediate vicinity but indicate that oil may be found of good quality where this same geological structure is capped by an impervious cover. Anticlines bear no very definite relation to surface topography, though the anticline is more likely to be found corresponding in a general way to the bottom of an old river or stream bed than corresponding to the divide between two streams.

Oil of good quality is usually found at sufficient depth that the lighter fractions have not evaporated, though some good wells are found at depths as shallow as 250 feet. The best wells of the Mid-Continent field vary from 1,000 to 3,500 feet in depth. The deepest well in the United States is in Harrison County, West Virginia, and is now 7,363 feet deep.

The preponderance of evidence points to the theory that the greater part of petroleum has been produced from vegetable matter undergoing decomposition in contact with salt water, followed by the segregation and accumulation in pervious rocks of the oil produced. Other theories are that oil originated from animal matter and also that it came from the reaction of metallic carbides at high pressure with water.

SUMMARIZED TABLE OF OIL OCCURRENCES IN THE UNITED STATES.

Field.	Structure.	Geologic Age.	Kind of Rock.	Kind of Petroleum.
Appalachian or Eastern	Geo-Syncline with subordinate anticlines	Ordovician to Carboniferous	Sandstone	Paraffin base
Ohio-Indiana	Anticlines	Ordovician	Mostly limestone	Paraffin base
Illinois	Low anticlines	Carboniferous	Sandstones	Paraffin and semi-paraffin base
Mid-Continent	Anticlines	Carboniferous	Sandstones	Paraffin and semi-paraffin base
Wyoming	Folds	Carboniferous to Tertiary	Mostly sandstone	Paraffin and asphalt base
Gulf Coast	Domes	Tertiary and Cretaceous	Dolomite and sandstone	Asphalt base
California	Folds and Faults	Tertiary	Sandstone shales and conglomerates	Asphalt base

DAILY PRODUCTION OF CRUDE OIL BY POOLS (end of 1917.)

	Bbls.	Bbls.
California Fields		271,535
Valley—		
Midway-Sunset	100,359	
Coalinga	42,910	
Kern River	22,712	
McKittrick	8,187	
Lost Hills-Belridge	17,828	
Coast—		
Santa Maria-Lomper	18,639	
Summerland	145	
South—		
Fullerton-Whittier	53,933	
Ventura County-Newhall	3,121	
Los Angeles-Salt Lake	3,701	
Wyoming Fields		35,500
Salt Creek Field	15,000	
Grass Creek Field	9,000	
Elk Basin Field	6,000	
Big Muddy Field	4,000	
Lander Field	1,000	
Greybull and Basin Field	500	
Coastal Gulf Fields		124,240
Texas-South—		
Sour Lake	8,750	
Goose Creek	19,500	
Humble	21,500	
Batson	1,750	
Saratoga	1,100	
Spindletop	935	
Markham	300	
Damon Mound	1,900	
Edgerly	2,000	
Jennings	2,200	
Vinton	3,825	
New Iberia	90	
Total	64,050	
Texas Panhandle Field—		
Electra, Burkburnett, Corsicana, etc.	34,000	
North Louisiana—		
Caddo and Northeastern Texas	18,950	
DeSoto and Red River	7,250	
Total	26,200	

Mid-Continent Field		410,749
Cherokee Deep Sand—		
Bartlesville	6,200	
Bird Creek	8,200	
Collinsville-Vera	325	
Copan-Wann	1,950	
Hogshooter	250	
Total	16,925	
Osage	35,000	
Cleveland	7,250	
Cherokee Shallow Sand	8,800	
Creek Nation—		
Bald Hill	8,000	
Bixby-Leonard	9,000	
Boynton-Cole	5,500	
Glenn Pool	18,000	
Cushing-Shamrock	56,220	
Hamilton Switch	550	
Henryetta	420	
Kellyville	410	
Lost City-Red Fork	600	
Morris	3,400	
Muskogee	375	
Mounds	1,450	
Perryman-Jenks-Broken Arrow	2,800	
Schulter	320	
Stone Bluff	1,600	
Tiger Flats	2,200	
Yale	13,000	
Total	123,845	
Kay County—		
Newkirk	500	
Ponca City	450	
Blackwell	8,100	
Total	9,050	
Southwest Oklahoma—		
Healdton	60,425	
Wheeler	425	
Lawton	125	
Allen	430	
Billings	1,300	
Garber	3,510	
Total	66,215	
Kansas—		
Eldorado	94,600	
Augusta	27,064	
Outside	22,000	
Total	143,664	
Kentucky Fields		12,765
Ravenna, Fitchburg, Pilot and Others.		

PRODUCTION AND DECLINE OF INDIVIDUAL OIL WELLS.

Mid-Continent Field—1916.

Total number of wells drilled during year	11,240
Total number of dry holes (including gas)	1,970
Total number with gas	475
Total producing at end of year	9,270
Per cent producing at end of year	82.5
Average production of this year's producing wells drilled during the year	26 Bbls.
Average production of all this year's producing wells including dry holes	21.5 Bbls.
Total number of wells drilled up to end of this year	81,150
Total number of wells drilled and producing at end of this year	43,420
Per cent of wells drilled now productive	53.2%
Average production of all producing wells in field per day including this year	8 Bbls.
Average production of all producing wells drilled excluding this year	3 Bbls.

WELLS DRILLED IN UNITED STATES IN 1917.

	Completed	Production	Dry	Gas
Pennsylvania	5,435	35,549	985	762
Lima-Indiana	800	12,318	140	17
Central Ohio	582	901	139	406
Kentucky-Tennessee	1,651	35,652	411	60
Illinois	647	10,138	151	7
Kansas	3,469	325,410	547	172
Oklahoma-Arkansas	6,717	360,896	1,334	409
Texas Panhandle	1,020	50,998	262	18
North Louisiana	472	60,299	110	56
Gulf Coast	1,562	490,571	639	57
Total, 1917	22,355	1,382,732	4,718	1,964

Wells drilled during year producing oil at end of year—70.11%.

This data shows that the chief decline in the amount of oil produced occurs in the first year of the life of the oil well. This decline occurs suddenly after the first gushing due to the sudden local relief of pressure. After this, there is a decline due to the gradual exhaustion of the sand. Every reservoir of oil is limited in capacity by the depth of the sand and the degree of impregnation with oil.

As a general rule, 500 barrels of oil is all that may be expected from each acre for each one foot depth of oil-bearing sand though this varies with the porosity and degree of saturation of the sand.

While the chief general cause for decline of oil wells is exhaustion of the sand, there are many causes that account for a decline in individual wells or localities.

Among these are:

(1) The diminution of the gas pressure.

(2) The localized exhaustion of sand.

(3) Paraffin and asphaltic sediments in the interstices of the sand due to volatilization of lighter constituents and selective filtration.

(4) Offset wells.

(5) Flooding by salt water from beneath.

(6) Flooding by water from upper strata.

(7) Drilling too deep into the sand.

(8) Cave-ins due to carrying out of sand in gushing period.

(9) Poor management in placing casing, time of pumping and in cleaning out.

OIL GUSHERS.

The largest oil well in the world is one which came in near Tampico, Mexico, Feb. 10, 1916. It was known as Cero Azul No. 4, and was drilled by the Pan-American Petroleum & Transport Co. The first 24 hours of oil flow yielded 260,000 barrels. In two years it is said to have produced approximately 60 million barrels of oil or about one-half of the total production of oil from Mexico. Its initial pressure was 1,035 pounds per square inch and the gravity of the oil is 21° Baume' and without sediment or water.

On account of the lack of transportation facilities, it has not been allowed to flow at its maximum, being restrained to one million barrels per month at this time.

A number of wells in the Saboontchy-Romany oil fields of Russia have given daily yields of from 75,000 to 120,000 barrels per day for weeks and as much as 7,500,000 barrels in a year.

Another Mexican well at Dos Bocas, south of Tampico, yielded approximately 5 million barrels within two months.

A well in the Jennings pool in Louisiana in 1904 is reputed to be the largest gusher in the United States and gave 1,275,000 barrels of oil in four months.

Wells in Texas, California and Roumania have yielded 60,000 to 75,000 barrels of oil per day on the initial production.

The largest wells in the Mid-Continent field were in Butler County, Kansas, where, in the Towanda pool, gushers as large as 25,000 barrels per day initial production were struck in 1917.

Refinery Operations on Crude Oil

	1916 Quantity	%	1917 (est.) Quantity	%
Crude Oil, bbls.	246,922,015		304,000,000	
Gasoline, bbls.	49,020,000	19.85	64,290,000	21.15
Kerosene, bbls.	34,655,000	14.03	39,710,000	13.06
Gas and Fuel, sold, used and loss, bbls.	134,290,000	54.37	158,100,000	52.02
Lubricating Oils, bbls.	14,870,000	6.02	17,070,000	5.61
Wax, lbs.	386,180,898	0.55	429,617,000	0.50
Coke, tons	405,319	1.04	477,123	0.99
Asphalt, tons	716,490	1.83	724,000	1.51
Miscellaneous, bbls.	5,696,000	2.31	15,700,000	5.16

REFINERY OPERATIONS BY DISTRICTS FOR FIRST 6 MONTHS OF 1917.

District	Crude Handled Barrels	% Gasoline	% Kerosene
Atlantic Coast	23,454,900	22 20%	22.16%
Pennsylvania District	8,659,200	24.69%	21.43%
Illinois District	13,830,300	35.92%	14.53%
Mid-Continent	29,260,260	26.95%	14.49%
Gulf Coast	27,543,470	12.65%	11.36%
Wyoming	4,035,800	37.43%	17.03%
California	36,403,400	11.14%	4.27%
Jan.-July, 1917	143,189,374	20.35%	13.04%

CRACKED GASOLINE MARKETED OVER FIVE-YEAR PERIOD.

Year	Barrels
1913	1,000,000
1914	3,000,000
1915	4,000,000
1916	6,000,000
1917	7,000,000

STRAIGHT RUN AND CRACKED GASOLINE ON BASIS OF TOTAL CRUDE PETROLEUM REFINED.

	Full Year 1916 %	First 6 Months 1917 %
Straight run gasoline	17.45	17.89
Cracked gasoline	2.40	2.44

TYPICAL PRICES OF PETROLEUM PRODUCTS JAN. 1, 1918.

Crude at the Wells.

Pennsylvania—light	$3.75
Corning, Ohio	2.80
Kentucky	2.55
Lima, Ohio	2.08
Illinois	2.12
Healdton 32° and above	1.20
Cushing	2.60
Garber	3.50
Mid-Continent and North Texas	2.00
Caddo—heavy	1.00
Caddo—light	2.00
Gulf Coast	1.00
Mexican (Texas ports)	1.50
Canada	2.48
Wyoming	1.70
California (average)	1.00

Refinery Products.

	Gasoline Gallon	Kerosene Gallon	Fuel Oil Barrel
At Refinery—Oklahoma	19.0c	8.0c	$1.50
Kansas City	20.3c	9.3c	1.85
Tulsa	25.0c	12.0c	1.70
Wichita	22.0c	10.0c	1.60
Topeka	19.7c	10.0c	1.75
New York City	24.0c	14.0c	4.00
Boston	25.0c	12.0c	4.00
Chicago	21.0c	10.5c	2.50
San Francisco and Los Angeles	20.5c	11.0c	1.45
Seattle	20.5c	14.0c	1.60
New Orleans	22.5c	10.5c	2.00

Paraffin wax	melting point	120	10¾c lb.
		125	11½c lb.
		128	12½c lb.
		133	15c lb.
		140	17c lb.

Lubricating Oil—

Natural	18c-20c per gal.
Black	19c-20c per gal.
Cylinder, pale	34c-48c per gal.
Cylinder, dark	24c-25c per gal.

Asphalt (at nearest market to refinery)—

50% asphalt Road oil—7c per gallon	$17.50 per ton
70% asphalt Road oil—8c per gallon	20.00 per ton
Texaco asphalt (Dallas)	26.00 per ton
California (San Francisco)	13.50 per ton
Mexican (Houston)	20.00 per ton
Trinidad (Kansas City)	26.00 per ton
Stanolind (Kansas City)	20.00 per ton

Natural Gas .... 3c to 60c per 1000 cu. ft.

Chemical Constitution of Petroleum

Petroleum is composed of carbon and hydrogen in chemical combination known as hydrocarbons. In conjunction with the carbon and hydrogen there frequently is oxygen, nitrogen and sulphur in much smaller amounts.

In crude oils the amount of carbon varies from 80 to 89%, the hydrogen from 10 to 15%, oxygen from 0.0 to 5.0%, nitrogen from 0.0 to 1.8% and sulphur from .01 to 5.0%.

Typical ultimate analyses of petroleum products are as follows:

	Carbon	Hydrogen	Sulphur	Nitrogen	Oxygen
Pennsylvania Crude	86.06%	13.88%	0.06%	0.00%	0.00%
Texas Crude	85.05	12.30	1.75	0.70	0.00
California Crude	84.00	12.70	0.75	1.70	1.20
Mexican Crude	83.70	10.20	4.15	....	....
Oklahoma Crude	85.70	13.11	0.40	0.30	....
Kas. Crude (Towanda)	84.15	13.00	1.90	0.45	....
Kansas Residuum	85.51	11.88	0.71	0.32	0.63
Kansas Air Blown Residuum	84.37	10.39	0.42	0.21	4.61
Byerlite Pitch	87.61	9.97	0.55	0.29	1.58
Grahamite	87.20	7.50	2.00	0.20	....
Trinidad Asphalt	82.60	10.50	6.50	0.50	....
Commercial Gasoline	84.27	15.73	0.00	0.00	0.00
Kerosene	84.74	15.26	0.01	0.00	0.00
Lubricating Oil (Paraffin)	85.13	14.87	0.01	....	....
Lubricating Oil (Naphthene)	87.49	12.51	0.01	....	....
Benzol	92.24	7.76	0.00	0.00	0.00

Paraffin (C_nH_{2n+2}) **hydrocarbons** largely compose the light or more volatile constituents of all petroleum. They are "saturated" hydrocarbons and have a very low ratio of specific gravity to distilling temperature, are not acted upon by concentrated sulphuric acid or by fuming sulphuric acid (oleum), are not nitrated by nitric acid and are extremely resistant to all chemical reactions. The chief differences in petroleum are in the heavy constituents, the heavy hydro-

carbons of the paraffin series being found chiefly in Pennsylvania and some Mid-Continent oils.

Naphthenes (C_nH_{2n}) ring or cyclic compounds are less common hydrocarbons in lighter portions of petroleum, but commonly found as heavy hydrocarbons of petroleum. They have a higher ratio of specific gravity to distilling temperature than the paraffin compounds, are resistant to the action of sulphuric acid and some types may be distinguished by the "formolit" reaction. Oils containing light naphthenes are found in Russia and Louisiana. All heavy oils contain naphthenes.

Aromatic or Benzene hydrocarbons (C_nH_{2n-6}) exist to some extent in certain California petroleums and have a very high ratio of specific gravity to distilling temperature. Gasoline made from the California petroleum is heavier than light gasoline with the same end point made from Mid-Continent petroleum. The aromatic compounds are acted upon by nitric acid forming nitro products. They are formed from paraffin and naphthene hydrocarbons by pyrogenic decomposition at temperatures above 1000°F. The production of aromatic compounds from petroleum has not been commercially satisfactory on account of incomplete conversion and difficulty of freeing from paraffin hydrocarbons.

Olefines or Ethylenes (C_nH_{2n}) are "unsaturated" hydrocarbons, rarely if ever existing naturally in crude oil but commonly resulting from its exposure to high temperatures. These compounds contain less hydrogen and more carbon than paraffin hydrocarbons and are capable of taking in more hydrogen. They are removed from aromatic compounds, paraffin compounds and naphthene compounds by the action of concentrated sulphuric acid in the usual process of refining gasoline. These hydrocarbons give gasoline, to a large extent, its disagreeable odor before refining. Their combination with sulphur gives a more intense odor. Each of these groups of hydrocarbons is supposed to exist in a complete series, represented by the general formula given. The paraffin or methane series of "saturated" hydrocarbons has been fairly well worked out and is given in the following table:

PARAFFIN HYDROCARBONS IN PETROLEUM.

GASEOUS HYDROCARBONS (Natural Gas)

Name	Baume' Gravity	Sp. Gr. Liquid 15.5°C	Formula	Melting Point	Boiling Point	Molecular Weight
Methane	...	....	CH_4	—184.0°C	—165.0°C	16.03
Ethane	194	0.432	C_2H_6	—171.4	— 93.0	30.05
Propane	142	0.515	C_3H_8	—195.0	— 45.0	44.07
Butane	109	0.585	C_4H_{10}	—135.0	+ 1.0	58.08

"GASOLINE" HYDROCARBONS

Name	Baume' Gravity	Sp. Gr. Liquid 15.5°C	Formula	Melting Point	Boiling Point	Molecular Weight
Pentane	92.2	0.630	C_5H_{12}	....	36.3	72.10
Hexane	78.9	0.670	C_6H_{14}	....	69.0	86.12
Heptane	70.9	0.697	C_7H_{16}	....	98.4	100.13
Octane	65.0	0.718	C_8H_{18}	....	125.5	114.15
Nonane	59.2	0.740	C_9H_{20}	— 51.0	150.0	128.16
Decane	56.7	0.750	$C_{10}H_{22}$	— 31.0	173.0	142.18
Undecane	54.2	0.760	$C_{11}H_{24}$	— 26.0	195.0	156.20

HEAVY LIQUID HYDROCARBONS (Kerosene)

Name	Baume' Gravity	Sp. Gr. Liquid 15.5°C	Formula	Melting Point	Boiling Point	Molecular Weight
Duodecane	51.8	0.770	$C_{12}H_{26}$	— 12.0	214.0	170.22
Tridecane	46.8	0.792	$C_{13}H_{28}$	— 6.0	234.0	184.24
Tetradecane	45.0	0.800	$C_{14}H_{30}$	+ 5.0	252.0	198.25
Pentadecane	43.5	0.807	$C_{15}H_{32}$	10.0	270.0	212.26
Hexadecane	41.8	0.815	$C_{16}H_{34}$	18.0	287.0	226.27
Heptadecane	40.3	0.822	$C_{17}H_{36}$	22.0	295.0	240.28
Octadecane	38.6	0.830	$C_{18}H_{38}$	28.0	317.0	254.30

HEAVY SOLID HYDROCARBONS

Name	Baume' Gravity	Sp. Gr. Liquid 15.5°C	Formula	Melting Point	Boiling Point (vacuo)	Molecular Weight
Eicosane	37.2	0.837	$C_{20}H_{42}$	37.0	117.5	282.34
Tricosane	36.5	0.841	$C_{23}H_{48}$	48.0	138.0	324.38
Tetracosane	..	....	$C_{24}H_{50}$	51.0	145.5	338.39
Pentacosane	..	....	$C_{25}H_{52}$	54.0	152.5	352.41
Hexacosane	..	....	$C_{26}H_{54}$	56.0	160.0	366.43
Mericyl	..	....	$C_{27}H_{56}$	59.4	167.0	370.45
Octocosane	..	....	$C_{28}H_{58}$	60.0	173.5	384.47
Nonocosane	..	....	$C_{29}H_{60}$	63.0	179.0	398.48
Ceryl	..	....	$C_{30}H_{62}$	65.6	186.0	422.49
Pentriacontane	..	....	$C_{31}H_{64}$	68.0	193.5	436.51
Duotriacontane	..	....	$C_{32}H_{66}$	70.0	201.0	450.53
Tetratriacontane	..	....	$C_{34}H_{70}$	72.0	215.0	478.56
Pentatriacontane	35.4	0.846	$C_{35}H_{72}$	75.0	222.0	492.58

There is no natural petroleum composed exclusively of the paraffin series of hydrocarbons, even Pennsylvania and Garber, Oklahoma, crude oils having members of other series. The main body of the light petroleum is made up of paraffin hydrocarbons and the heavy residues are largely made up of naphthenes.

According to Hofer, the following olefines have been isolated from "North American" petroleum:

Ethylene	C_2H_4	Heptylene	C_7H_{14}	Dodecylene	$C_{12}H_{14}$
Propylene	C_3H_6	Octylene	C_8H_{16}	Decatrilene	$C_{13}H_{26}$
Butylene	C_4H_8	Nonylene	C_9H_{18}	Cetene	$C_{16}H_{32}$
Amylene	C_5H_{10}	Decylene	$C_{10}H_{20}$	Cerotene	$C_{27}H_{54}$
Hexylene	C_6H_{12}	Endecylene	$C_{11}H_{22}$	Melene	$C_{30}H_{60}$

If the residue contains much wax, the crude is known as paraffin base oil, but if naphthenes or similar hydrocarbons predominate, it is an "asphalt" base oil. Practically the "asphalt" is determined by the solubility of the solid hydrocarbons in pentane and by the gravity and physical character of the residue.

Among the light hydrocarbons of petroleum, either existing naturally or pyrogenically produced, the relation of the specific gravity to the distilling temperature affords a simple and practical method of estimating the amount of olefin, paraffin and aromatic compounds. This relation is set forth in the curves on page 105.

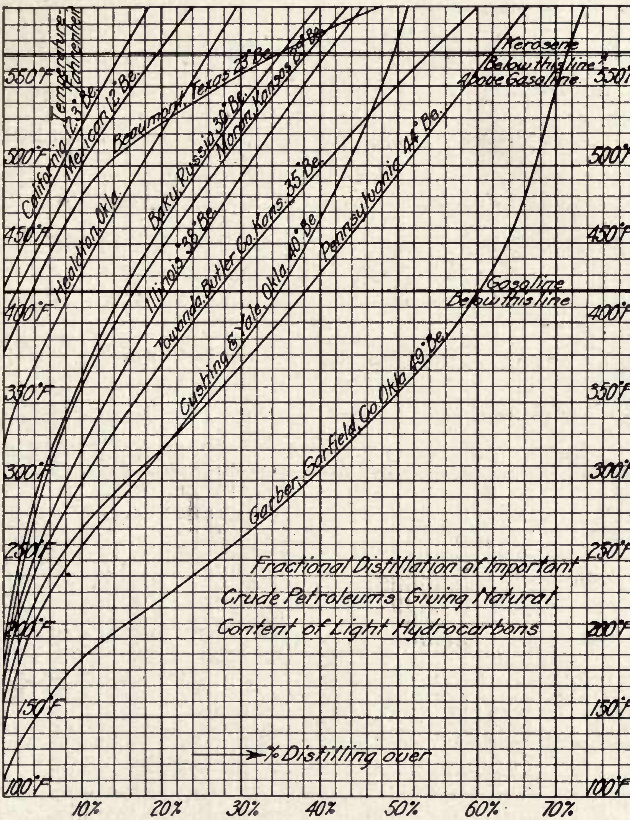
The value of crude oil is not measured by its ultimate analysis or by its "base" so much as by the amount of volatile constituents which it contains. The amount of volatile constituents obtained from various crude oils is shown by the curves on page 23.

The natural commercial content of various crude oils is as follows:

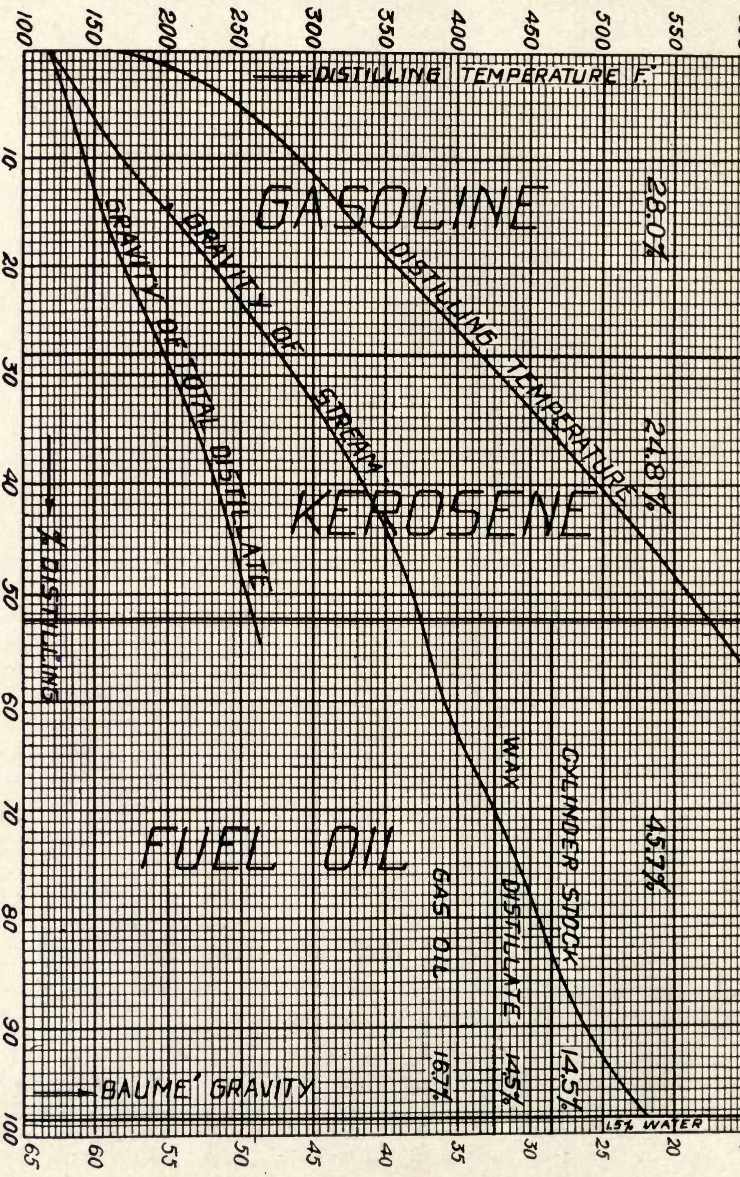
CONTENT OF CRUDE OILS (Typical Samples).

Source	Specific Gravity	Natural Commercial Automobile Gasoline, % by Vol. to 410° F	Kerosene, 410° F, 572° F, % by Volume	Total Obtainable Gasoline, Natural and Artificial (KCTL Test), % by Vol. (See Page 107)
Garber, Garfield County, Okla.	49.5°Be′ 0.780	60.0%	10.8%	91.0%
Pennsylvania (Light)	44.5°Be′ 0.802	37.5%	12.7%	86.2%
Cushing, Oklahoma	40.1°Be′ 0.823	35.0%	15.0%	83.7%
Towanda, Butler County, Kansas	34.7°Be′ 0.850	26.5%	27.5%	77.9%
Neodesha, Wilson County, Kansas	33.3°Be′ 0.860	25.0%	17.0%	81.2%
Newkirk, Oklahoma	40.3°Be′ 0.822	32.5%	24.0%	83.1%
Mexican	11.4°Be′ 0.990	2.0%	18.0%	46.1%
California	12.3°Be′ 0.984	0.0%	12.3%	50.0%
Texas (Beaumont)	23.4°Be′ 0.912	4.0%	16.0%	61.6%
Russia	30.2°Be′ 0.874	15.0%	20.0%	....
Healdton, Okla.	22.1°Be′ 0.920	8.5%	17.5%	64.0%
Moran, Kansas (Allen County)	30.7°Be′ 0.871	15.0%	17.5%	74.5%
Kentucky (Wayne County)	37.7°Be′ 0.835	28.0%	21.0%	....
Wyoming (Lander County)	24.0°Be′ 0.909	13.0%	13.0%	....

Gravity of other crude oils: Paola, Kas., 31.4°; Allen County, Kansas, 19-31°Be′; Neosho County, Kansas, 23-30°Be′; Chautauqua County, 32-34°Be′; Augusta, Kas., 32-34°; Eldorado, 36-40°Be′; Glenn Pool, 36-38°Be′; Healdton, 22-32°Be′; Fox Pool, 45°Be′.



Diagrammatic Proximate Composition of crude petroleum as to gasoline and kerosene.



METHOD OF GRAPHIC REPRESENTATION OF COMMERCIAL COMPOSITION OF CRUDE OIL.

Typical Refinery Practice

There is considerable variation in the practice of petroleum distillation in different refineries, owing principally to the variation in the crude oil supplied to the trade to which the refinery sells, and to the ability of the refiner both as to knowledge and equipment.

The following is an outline of the progressive distillation and treatment of crude oil in one refinery:

1. **Crude Benzine** distillate (**Gasoline and Naphtha**) includes all light oil up to about 52° gravity, dependent upon the gravity of the crude, and is usually distilled by the direct fire heat under the still.

   This distillate is put into an agitator with sulphuric acid for purification and the acid is washed out with caustic soda and water. This is then re-distilled until a gravity of about 61 is attained in the mixed distillate, and is **gasoline**, ready for the market. The remainder of the distillate is sold as the **naphtha** used for various chemical purposes.

2. The **Kerosene** distillate comes over just after the crude benzine distillate and until an oil of about 41 gravity is reached. It is desired to stop before there is discoloration from decompo sition or "cracking" of the oil. This "first run" kerosene is then treated as in the case of the benzine distillate and redistilled, preferably with steam, to get a water white kerosene of about 43° gravity. The heavy end may be mixed with the solar oil.

3. The **Solar Oil (distillate oil)** distillate is stopped at about 37° gravity after the kerosene, and is usually not refined, being used in explosion oil engines and fuel oil burners.

4. The **Gas Oil** is obtained immediately following the distillate oil, and its distillation is continued until the residuum in the still has a gravity of 24-26°Baume'. It is distinctly a destructive distillation. This oil is used in making gas and contains a considerable amount of olefins and cracked products and is not refined except for special purposes.

5. The **Residuum** or tar is sold for **fuel oil**, or it may be used to produce lubricating oils. In the latter case it may be put into the coking stills and run down to **coke**. The distillate is treated with 66° commercial sulphuric acid in an agitator, is washed and refrigerated and the **paraffin** is removed.

6. The filtrate from the paraffin or **pressed distillate** is redistilled with steam to produce **lubricating oils** of the desired gravity, viscosity, etc. The heaviest residual oil is usually the steam cylinder lubricating oil stock. The most careful refining is required for automobile cylinder oils in order to obtain low fixed carbon to prevent separation of free carbon in the cylinder in use.

When **asphalt** is desired, the residue from the gasoline and kerosene is distilled by blowing superheated steam through it until the desired consistency is reached. In the ordinary skimming or topping plant the gasoline alone is taken off. This, in the usual Mid-Continent crude, means a 58° Baume′ product with an end point of about 410°F. Many skimming plants operating on high grade crudes, such as from Cushing, Yale, Blackwell and Garber pools, do not refine their gasoline with acid, and sell only gasoline or naphtha and fuel oil. The fuel oil in this case is very fluid and is preferred over the heavy fuel oil. (See also page 75.)

Refineries in the United States

(This information is taken largely from the more reliable oil trade journals, such as "Petroleum" of Chicago; Oil, Paint & Drug Reporting, New York; Oil and Gas Journal, Tulsa).

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
ALABAMA				
Alabama Oil & Development Co.	Mobile	(Bldg.)		
ARKANSAS				
Ozark Oil & Refining Co.	Fort Smith	1914	$ 75,000	300
CALIFORNIA				
Beckett Refining Co.	Arroyo Grande			
Associated Oil Co.	Avon	1912	1,400,000	12,500
Union Oil Co. of California	Avilla	1895	3,200,000	30,000
		(All Union Oil plants)		
Phoenix Refining Co.	Bakersfield	1902	300,000	1,200
Union Oil Co. of California	Bakersfield	1895		
Vulcan Oil Co.	Bakersfield	1901		400
Capital Refining Co.	Berkeley	1900		600
Monarch Oil Refining Co.	Berkeley	1910		
Pinal Dome Refining Co.	Betteravis	1911	560,000	1,950
Union Oil Co. of California	Brea	1895		
Columbian Oil, Asphalt & Ref.	Carpanteria			
O'Neal Refining Co	Casmalia			
Puento Oil Co.	Chino	1892	200,000	600
Paraffin Paint Co.	Emeryville	1895	100,000	300
American Refining Co.	Fellows	1912	150,000	3,000
Ventura Refining Co.	Fillmore	1915	650,000	1,500
California-Fresno Oil Co.	Fresno	1901	50,000	160
Anaheim Union Water Co.	Fullerton			500
Associated Oil Co.	Gaviota	1899	530,570	
Moore Refining Co.	Goleta			
California Liquid Asphalt Co.	Hadley			
Ensign-Baker Refining Co.	Hadley	1910		1,000
Hanford Oil Refining Co.	Hanford	1913	45,000	250
King Refining Co.	Kern River	1901	175,000	500
Producers Refining Co.	Kern River	1904	65.000	150
Standard Oil Co.	Kern River	1914	98,750,000	65,000
		(All S. O. plts. in Calif.)		
Buckeye Refining Co.	Kern River	1901		
Warren Bros.	Kern River	1914	100,000	1,500
General Petroleum Co.	Kerto	1913	10,000	100
California Oil & Asphalt Co.	Los Angeles	1911	100,000	1,000
Continental Oil Co.	Los Angeles	1907		600
Densmore-Stabler Refining Co.	Los Angeles	1902	75,000	650
Golden State Oil Co.	Los Angeles	1912	30,000	150
Guaranty Oil Co.	Los Angeles			1,000
Huasteca Petroleum Co.	Los Angeles			
Jordan Oil Co.	Los Angeles			
Pioneer Roll Paper Co.	Los Angeles	1904	80,000	500
Service Oil & Asphalt Co.	Los Angeles	1892	100,000	800
Shell Co. (Trumbull process)	Los Angeles			5,000
Southern Refining Co.	Los Angeles	1900		700
Turner Oil Co.	Los Angeles		135,000	
Union Oil Co. of California	Los Angeles	1895		
Wilshire Oil Co. (old Atlas)	Los Angeles			600
Yosemite Oil Refining Co	Los Angeles	1898	30,000	600
Adeline Con. Road Oil Co.	Maricopa	1913	52,000	250
Sunset Monarch Oil Co.	Maricopa	1907		1,000
Amercan Oriental Co. (shell)	Martinez			6,000

REFINERIES IN THE UNITED STATES—Continued.

California—Continued.

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Dutch Shell Co. of Calif.	Martinez	1915	2,500,000	25,000
Vernon Oil Co.	Los Angeles		21,000	
Western Oil Co.	Los Angeles		81,000	
General Petroleum Co.	Mojave	1914		8,000
Richfield Oil Co.	Olinda			800
Union Oil Co. of California	Orcutt	1895		
Sunset Oil & Refining Co.	Ostend	1903		2,000
Producers & Refiners' Oil Co.	Oil Port	1906		5,000
Standard Oil Co.	Point Richmond	1902		
Miliff Refining Co.	Redeo			
Warren Bros.	Redeo	1903	80,000	800
San Diego A-1 Refining Co.	San Diego	1911	30,000	300
Pacific Roofing & Refining Co.	San Francisco	1903		300
Prutzman Refining Co.	San Francisco			
West Coast Ref. Co.	San Francisco			
Union Oil Co. of California	San Pedro			
Capital Crude Oil Co.	Santa Paula			
El Merito Refining Co.	Santa Paula			
Union Oil Co. of California	Santa Paula			
A. F. Gilmore	Sherman			1,000
Tulara Refining Co.	Tulara			
Amalgamated Oil Co.	Vernon		75,000	3,500
Asphaltum Oil & Refining Co.	Vernon		50,000	500
British-California Oil Co.	Vernon			6,000
General Petroleum Co.	Vernon	1913	300,000	8,000
Hercules Oil Refining Co.	Vernon	1900	250,000	1,000
Jordan Oil Co.	Vernon	1907	125,000	200
Martin-Holloran Refining Co.	Vernon			
Richfield Oil Co.	Vernon	1907	175,000	2,000
Turner Oil Co.	Vernon			
National Oil Refining Co.	Waits	1906	85,000	150

COLORADO

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
The Inland Refinery	Boulder	1906	125,000	1,500
Florence Oil Co.	Florence	1889	200,000	1,000
United Oil Co. (Standard)	Florence	1887	500,000	3,000
Urado Oil Co.	Unitah Basin	1917	10,000	100

FLORIDA

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Jackson E. R. & Co.	Jacksonville	(Bldg.)	150,000	1,500

IDAHO

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Idaho Oil & Refining Co.	Pocatello	(Bldg.)	50,000	

ILLINOIS

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Midland Oil & Refining Co.	Allendale	1917		
Roxana Petroleum Corporation	Alton	1917	1,000,000	5,000
Standard Oil Co.	Wood River	1912	3,250,000	20,000
Erie Oil & Gas Co.	Bridgeport	1912	30,000	500
Leader Refining Co.	Casey		250,000	500
Oil Jobbers Prod. & Ref. Co.	Chicago	1917		
Republic Oil & Refining Co.	East Moline	1917	500,000	2,500
Anderson & Gustafson	East St. Louis	1916	5,000	200
Consolidated Oil Ref. Co. No. 2	East St. Louis	1909	50,000	1,000
Consolidated Oil Ref. Co. No. 3	East St. Louis	1915	35,000	300
Indiahoma Refining Co.	East St. Louis	1907	150,000	1,500
St. Clair Gas & Electric Co.	East St. Louis	1914	40,000	Idle
Great Northern Refining Co.	Joliet	1917	300,000	
Central Refining Co.	Lawrenceville	1908-9	3,000,000	3,000
Indian Refining Co.	Lawrenceville	1910	1,320,000	11,000
The Texas Company	Lockport	1911	1,225,000	3,000
Wabash Refining Co.	Robinson	1907	250,000	600
Smith Oil & Refining Co.	Rockford		75,000	300

REFINERIES IN THE UNITED STATES—Continued.

INDIANA

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Sinclair Oil & Refining Co.	Whiting	(Bldg.)	2,000,000	
Standard Oil Co. of Indiana	Whiting		25,400,000	60,000

IOWA

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Washington Refining Co.	Cedar Rapids	(Bldg.)	90,000	

KANSAS

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Sinclair Refining Co.	Argentine	1917		4,500
Kanotex Refining Co.	Arkansas City	1906	700,000	2,500
Lesh Refining Co.	Arkansas City	1914	300,000	1,200
Milliken Refining Co.	Arkansas City	1917	1,150,000	6,000
Augusta Refining Co.	Augusta	1917	200,000	3,000
Bliss Oil & Ref. Corp.	Augusta	1917		
Walnut River Refining Co.	Augusta	1916	125,000	1,500
White Eagle Refining Co.	Augusta	1917	750,000	5,000
Good Eagle Refining Co.	Baxter Springs	1917	50,000	600
Kanotex Refining Co.	Arkansas City	1906	650,000	800
Chanute Refining Co.	Chanute	1907		1,600
Kansas Co-operative Refin. Co.	Chanute	1906	200,000	800
Morgan Refining Co.	Chanute	1904	6,000	50
Rollin Oil Refinery	Chanute	1904	20,000	100
Sinclair Refining Co.	Chanute	1907		2,200
Uncle Sam Oil Co.	Cherryvale	1906	125,000	500
Wright Producing & Ref. Co.	Cherryvale	1917	100,000	1,000
Cudahy Refining Co.	Coffeyville	1909		4,500
Kansas Oil Refining Co.	Coffeyville	1906	350,000	1,250
National Refining Co.	Coffeyville	1907	525,000	4,600
Sinclair Refining Co.	Coffeyville	1909		4,500
Craig & Kaufman	El Dorado	(prop.)		
El Dorado Refining Co.	El Dorado	1916	250,000	2,000
Inland Refining Co.	El Dorado			
Lynch H. T. & Co.	El Dorado	1917	200,000	3,000
Midland Refining Co.	El Dorado	1917	250,000	4,000
Piper & Bolene	El Dorado	1917	100,000	1,000
Trapshooters Refining Co.	El Dorado	1917	100,000	1,000
Great Western Petroleum Corp.	Erie	1905	750,000	
Miller Petroleum Refining Co.	Humboldt	1906	73,626	505
Hutchinson Refining Co.	Hutchinson	1915	125,000	1,500
Empire Refineries (Sarco)				
Petroleum Products Co.	Independence	1909	2,750,000	3,000
General Refining Co.	Kansas City	1909	100,000	800
Kansas City Refining Co.	Kansas City	1906	300,000	2,700
Commonwealth Oil & Refin. Co.	Moran	1905	350,000	300
Standard Oil Co. of Kansas	Neodesha	1892	5,250,000	9,000
O. K. Refining Co.	Niotaze	1906	400,000	1,200
Red Ball Oil & Refining Co	Ottawa	1917	75,000	1,000
Oklamade Oil Refining Co.	Rantoul	1917	100,000	1,000
North American Refining Co.	Rosedale	1915	75,000	500
Evans-Thwing Refining Co.	Wichita	1917	350,000	3,000
Golden Rule Refining Co.	Wichita	1917	35,000	500
Kanita Refining Co.	Wichita	(prop.)		
Sterling Oil & Refining Co. (Hale Petroleum Co.)	Wichita	1917	500,000	5,000
Western Refining Co.	Wichita	1917	35,000	800
Wichita Indep. Oil & Ref. Co.	Wichita	1914	15,000	500
Wichita Indep. Oil & Ref. Co.	Wichita	1917	200,000	4,000

KENTUCKY

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Standard Oil Co.	Barbourville	1916	1,000,000	2,500
Victor Refining Co.	Barbourville	(prop.)		
Indian Refining Co.	Georgetown			Idle
Kentucky Produce & Ref. Co.	Irvine (bldg.)	1917	1,500,000	30,000
Southern Oil Refining Co.	Lexington (bldg)	1917		
Melick Refining Co.	Lexington	1917	100,000	1,500

REFINERIES IN THE UNITED STATES—Continued.

Kentucky—Continued.

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Aetna Refining Co.	Louisville	1917	200,000	3,000
Security Prod. & Ref. Co.	Louisville	1917	1,000,000	3,500
Victor Refining Co.	Louisville	1917		6,000
Oleum Refining Co.	Pryse	1917	125,000	1,000
Pioneer Ref. Co.	Rodemer	1918	100,000	1,000
LOUISIANA				
Federal Oil & Refining Co.	Alexandria	1915	150,000	1,000
Standard Oil Co.	Baton Rouge	1910	6,000,000	20,000
Marine Oil & Refining Co.	Cedar Grove	1917	500,000	
Pelican Oil & Refining Co.	Chelmette	1915	25,000	300
Red River Refining Co.	Crichton			
Mexican Petroleum Corporation	Destrahan	1916	2,000,000	2,000
Louisianan Oil Refining Co.	Gas Center	1912	1,350,000	2,000
Corona Oil Co. (Dutch Shell Co.)	New Orleans	1916	2,000,000	10,000
Freeport & Tampico Fuel Oil Co.	New Orleans	(prop.)		
Liberty Oil Co., Ltd.	New Orleans	1915	40,000	300
New Orleans Ref. Co. Dutch Shell.	New Orleans	1917		
Record Oil Refining Co.	New Orleans			
Sinclair Gulf Corp.	New Orleans			
Southern Oil Co., Inc.	Plaquemine (prop.)			
Gasoline Corporation	Sarpy (Greenstreet)	prop		1,200
Shreveport & Mex. Fuel Oil Co.	Saxonholm prop.			
American Oil Refinery Inc.	Shreveport		50,000	150
Caddo Oil Refinery	Shreveport	1913	125,000	2,000
Consolidated Oil Refining Co.	Shreveport	1916	2,000,000	2,400
Developers' Oil & Refin. Co.	Shreveport	1915	250,000	
Purified Petroleum Products	Shreveport		75,000	500
Shreveport Oil Refining Co.	Shrieveport	1911	50,000	1,300
MARYLAND				
Prudential Oil Corporation	Baltimore	1915	1,750,000	4,000
Standard Oil Co. of New Jersey	Baltimore		2,750,000	10,000
Gasoline Corporation	Curtis Bay	1917		
Inter-Ocean Oil Co.	East Brooklyn	1913	250,000	1,500
U. S. Asphalt Refining Co.	East Brooklyn	1911	1,000,000	5,000
Red "C" Oil Manufacturing Co.	Highland Town		350,000	725
MASSACHUSETTS				
Galena-Signal Oil Co.	Boston			300
MINNESOTA				
Pure Oil Co.	Minneapolis	1917	40,000	300
MISSOURI				
Indiahoma Refining Co.	Edwardsville	1917		
Wilhoit Refining Co.	Joplin	1914	150,000	750
Evans-Thwing Refining Co.	Kansas City	1917	500,000	4,000
North American Refining Co.	Kansas City	1917	150,000	4,000
St. Jos. Viscosity Oil & Ref. Co.	St. Joseph	1915	25,000	300
Anderson & Gustafson	St. Louis	1916	5,000	200
Standard Oil Co. of Indiana	Sugar Creek	1917	3,000,000	15,000
MONTANA				
Dillon Oil Co.	Butte	(bldg.)	50,000	
NEW JERSEY				
Columbia Oil Co. of N. Y.	Bayonne			1,000
Standard Oil Co. of N. J.	Bayonne	1873	37,000,000	45,000
Tidewater Oil Co.	Bayonne	1879	33,000,000	10,700
Standard Oil Co. of N. J.	Bayway	1914	15,000,000	40,000

REFINERIES IN THE UNITED STATES—Continued.

New Jersey—Continued.

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Vacuum Oil Co.	Bramwell's Pt.	1917	200,000	2,000
Barbour Asphalt Co.	Carteret			
Valvoline Oil Co.	Edgewater		200,000	1,000
Galena-Signal Oil Co.	Elizabeth		500,000	
Columbia Refining Co.	Jersey City		50,000	100
Standard Oil Co. of N. J.	Jersey City	1871	10,000,000	15,000
Warner-Quinlan Asphalt Co.	Maurer	1916	25,000	1,000
Vacuum Oil Co.	Paulsboro	1916	2,000,000	2,000
NEW MEXICO				
Oil Refinery	Farmington	1915	20,000	150
NEW YORK				
Standard Oil Co. of N. Y.	Buffalo			
Mexican Petroleum Co.	Mariner's Harbor			
Standard Oil Co. of N. Y.	New York City	1882	55,000,000	20,000
Vacuum Oil Co.	Olean	1883	5,000,000	12,000
Vacuum Oil Co.	Rochester			
Wellsville Refining Co.	Wellsville	1901	664,000	500
OHIO				
Canfield Oil Co.	Cleveland	1907	150,000	300
Clarke, Fred G., Co.	Cleveland		150,000	1,500
Great Western Oil Co.	Cleveland			400
Industrial Oil & Ref. Co.	Cleveland			
Lake Carriers Oil Co.	Cleveland		75,000	500
Mae Oil & Refining Co.	Cleveland prop.	1917	15,000	200
Standard Oil Co. of Ohio	Cleveland	1870	3,500,000	1,500
Middle West Refining Co.	Columbus		50,000	1,000
National Refining Co.	Findlay			1,000
Craig Oil Co.	Ironville	1891	250,000	1,200
Solar Refining Co.	Lima	1886	2,500,000	10,000
National Refining Co.	Marietta			500
Paragon Refining Co.	Toledo			1,000
Sun Oil Co.	Toledo			1,000
Oil Refining & Devel. Co.	Urbana	1917		
OKLAHOMA				
Greater Oil, Gas & Mfg. Co.	Ada	1917	600,000	
Crystal White Ref. Co.	Allen	1915	25,000	175
Ardmore Refining Co.	Ardmore	1914	200,000	4,528
Cameron Refining Co.	Ardmore	1917		1,000
Chickasha Refining Co.	Ardmore	1917		2,000
Great Western Refining Co.	Ardmore	1917		1,000
Imperial Refining Co.	Ardmore	1917	20,000	1,000
International Refining Co.	Ardmore	1914		5,800
Bigheart Petrol. Ref. Co.	Bigheart	1908	100,000	800
Bixby Oil & Ref. Co.	Bixby	1917	200,000	2,000
Economy Oil & Ref. Co.	Blackwell	1916	120,000	1,500
Modern Refining Co.	Blackwell	1918	250,000	
Cosden & Co.	Bigheart	1908		600
Boynton Refining Co.	Boynton	1916	90,000	1,000
Major Refining Co.	Boynton	1917		
Continental Refining Co.	Bristow	1914	275,000	1,500
Misener, F. D.	Broken Arrow prop.			
Marion Refining Co.	Chelsea prop.			
Great Central Refining Co.	Claremore	1917	500,000	
Consolidated Refining Co.	Cleveland	1913	85,000	650
Webster Refining Co.	Coalton	1911		Idle
Superior Oil Ref. Co.	Covington	1917	50,000	500
Chenning Refining Co.	Cushing	1917	20,000	
Commonwealth Cotton Oil Co.	Cushing			
Consumers Refining Co.	Cushing	1913	1,150,000	5,000

REFINERIES IN THE UNITED STATES—Continued.

Oklahoma—Continued.

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Cosden & Co	Cushing	1911		2,000
Cushing Acid Works	Cushing			
Cushing Petroleum Products Co	Cushing	1917	30,000	450
Ames Refining Co	Cushing			
Dean Oil Co	Cushing	1916	25,000	Idle
Eagle Refining Co	Cushing			
Empire Refineries (Cushing Ref.)	Cushing	1912		3,250
Federal Refining Co	Cushing			
Hawley, E. A	Cushing prop.			400
Hillman Refining Co	Cushing	1914	27,000	450
Holly & Owens	Cushing	1917	15,000	600
Illinois Oil Co	Cushing	1914	175,000	2,000
Inland Refining Co	Cushing	1917	350,000	2,500
International Refining Co	Cushing	1915	300,000	4,365
Lavery-Ernst Oil Co	Cushing			
Peerless Refining Co. (Empire)	Cushing	1914	651,000	3,000
Premier Petroleum Products Co	Cushing			
Process Refining Co	Cushing	1917	20,000	600
Roxana Petroleum Co	Cushing	1916	1,250,000	10,000
Sinclair Oil & Ref. Co. (Chanute)	Cushing	1914		4,500
Tri-County Oil & Gas Co	Cushing	1917		
Wallace Refining Co	Cushing		50 000	
Central Refining Co	Drumright	1917	15,000	300
Danciger Oil & Refining Co	Drumright	1917	20,000	
Interstate Oil Refining Co	Drumright	1917		
Oil Refinery	Drumright	1917	250,000	
Bu-Co Oil & Refining Co	Enid	1917	10,000	
Champlin Refining Co	Enid	1917	75,000	1,500
Globe Oil & Refining Co	Enid	1917	500,000	5,000
Oil State Refining Co	Enid prop.		250,000	
Southwestern Oil Corporation	Enid	1917		
Superior Refining Co. (Bldg.)	Enid	1917		
Gotebo Refining Co	Gotebo	1917	10,000	100
Carbo Oil Refining Co	Guthrie			
Forty-six Star Refining Co	Healdton	1917		
Cameron Refining Co	Healdton prop.			
Henryetta Refining Co	Henryetta	1917	10,000	
Osage Refining Co	Hominy	1917	30,000	1,000
Wabash Refining Co	Hominy	1917	100,000	1,000
Great American Refining Co	Jennings	1917	150,000	1,500
Acme Ref. & Pipe Line Co	Jennings		250,000	2,500
Odessa Oil & Refining Co	Jennings	1917	100,000	
Republic Refining Co	Jennings			
McKirschner Refining Co	Jennings	1917	50,000	600
Lawton Refining Co	Lawton	1916	27,000	400
North Iowa Oil & Refining Co	Lawton	1917	50,000	
Birmingham Oil & Gas Co	Muskogee	1917	1,000,000	
Haskell Refining Co	Muskogee	1917	150,000	
Muskogee Refining Co	Muskogee	1905	1,250,000	1,500
Nupro Refining Co	Muskogee	1917	50,000	800
Sinclair Oil & Ref. Co. (Cudahy)	Muskogee	1905		500
Crescent Refining Co	Newkirk	1917	200,000	3,000
Dilworth Oil & Refining Co	Newkirk	1917		
Nvanza Refining Co	New Wilson	1917	50,000	1,400
Triangle Oil Refining Co	New Wilson	1917	35,000	
Terminal Refining Co	New Wilson prop.			1,000
Wilson Refining Co	New Wilson		75,000	
Carter Oil Co	Norfolk	1916	3,500,000	18,000
Nowata Oil Refining Co	Nowata	1917	500,000	
Oilton Refining Co	Oilton	1917	15,000	500
Equality Refining Co	Oilton		100,000	
Riverside Refining Co	Oilton		300,000	1,500
Atwood Refining Co	Oklahoma City	1915	50,000	1,000
Capital Refining Co. of Okla	Oklahoma City	1915	20,000	300
Consumers Refining Co. of Okla	Oklahoma City prop.		250,000	
Corton Oil & Refining Co	Oklahoma City	1917	100,000	
Empire Refineries (Okla. Ref. Co.)	Oklahoma City	1906		2,000

REFINERIES IN THE UNITED STATES—Continued.

Oklahoma—Continued.

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Home Oil Co.	Oklahoma City	1917	500,000	2,500
Pyramid Refining Co.	Oklahoma City	1917	100,000	
Security Refining Co.	Oklahoma City	1917	150,000	
Wallace Refining Co.	Oklahoma City	1917	50,000	
Allied Refining Co.	Okmulgee	1917		
Denver Producing & Refining Co.	Okmulgee	1917		
Empire Refineries (American Ref.)	Okmulgee	1907		4,000
Indiahoma Refining Co.	Okmulgee	1910	1,258,000	3,750
Lake Park Refining Co.	Okmulgee	1915	40,000	800
Okmulgee Producing & Ref. Co.	Okmulgee	1916	200,000	1,500
Oneta Refining Co.	Oneta	1917	40,000	500
Limbocker Oil & Ref. Co.	Paul's Valley prop.		150,000	1,000
Osage Mutual Refining Co. (Bldg.)	Pawhuska	1917		
North American Refining Co.	Pemeta	1915	200,000	2,000
Empire Refineries (Ponca Ref. Co.)	Ponca City	1912		3,500
Lake Park Refining Co.	Ponca City		100,000	
Marland Refining Co.	Ponca City		2,500,000	
W. D. Richardson (Bldg.)	Ponca City	1917		
Peoples Refining Co.	Ringling	1917	50,000	500
Mohawk Refining Co. (Bldg.)	Sand Springs	1917		
Phoenix Refining Co.	Sand Springs	1913	350,000	3,500
Pierce Oil Corporation	Sand Springs	1913	1,250,000	5,000
Wabash Refining Co.	Sand Springs	1917	250,000	5,000
Duluth Refining Co.	Sapulpa	1917	175,000	3,000
Paramount Oil & Refining Co.	Sapulpa	1917		
Sapulpa Refining Co.	Sapulpa	1908	2,000,000	5,500
Victor Refining Co.	Sapulpa	1917	100 000	1,000
Shawnee Refining Co.	Shawnee	1917	100,000	
Black Hawk Petroleum Co.	Stone Bluff			
Mayfield Oil & Ref. Co. (Bldg.)	Terlton	1918		1,500
Bliss Oil & Refining Co.	Tulsa	1917	3,000,000	
Brazilian Oil & Refining Co.	Tulsa	1917	100,000	
Constantin Refining Co.	West Tulsa	1911	450,000	5,300
Consumers Oil & Ref. Co.	West Tulsa		340,000	
Cosden & Co.	West Tulsa	1913		13,000
Federal Refining Co.	Tulsa	1917	50,000	
Jayhawker Refining Co.	Tulsa	1917	100,000	
Kingsmith Refining Co.	Tulsa	1917		
Mid-Continent Gasoline Co.	West Tulsa	1916	150,000	2,000
Phoenix Refining Co.	Tulsa		300,000	
Okla. Producing & Gasoline Co.	West Tulsa	1917		
Mohawk Refining Co.	West Tulsa			
Pan-American Refining Co.	West Tulsa	1916	275,000	2,500
The Texas Company	West Tulsa	1910		8,500
Uncle Sam Oil Co.	West Tulsa	1906	50,000	600
Western Products & Refining Co.	Tulsa	1917	1,000	
Western Glow Oil & Ref. Co.	Tulsa			
White Star Refining Co.	West Tulsa	1917	100,000	1,500
Milliken Refining Co. (Sinclair)	Vinita	1910		6,000
Wilson Refining Co. (Healdton)	Wilson	1917	20,000	1,000
Canfield Refining Co.	Yale	1917	250,000	1,000
Home Oil Refining Co.	Yale	1916	40,000	500
Interstate Oil & Refining Co.	Yale			
Katy Refining Co.	Yale	1916	15,000	200
Pawnee Oil & Refining Co.	Yale	1917	30,000	
Southern Oil Corporation	Yale	1915	700 000	4,500
Star Refining Co. (Interstate)	Yale	1916	16,000	600
Sun Company	Yale	1915	100,000	2,500
Superior Refining Co.	Yale	1916	21,000	190
Victor Refining Co.	Yale	1916-17	100,000	1,000
Webster Oil & Gasoline Co.	Yale	1915	80,000	800
Webster-Canfield Ref. Co.	Yale prop.			
Yale Oil Refining Co.	Yale	1916	30,000	1,000

REFINERIES IN THE UNITED STATES—Continued.

PENNSYLVANIA

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Donecker-Hiller Oil Ref. Co.	Allentown	1917	25,000	
Emery Manufacturing Co.	Bradford	1888	610,500	1,200
Kendall Refining Co.	Bradford	1882	400,000	400
Butler County Oil Ref. Co.	Bruin	1911	400,000	600
Valvoline Oil Co.	Butler			1,000
East Welbourne Oil Co.	Butler		500,000	
Inter-Ocean Oil Co.	Chester			
Manufacturer's Paraffin Co.	Chester			
Clarendon Refining Co.	Clarendon	1885	220,000	1,300
Levi Smith, Ltd.	Clarendon	1890	150,000	325
Tiona Refining Co.	Clarendon	1886	236,000	400
Amber Oil & Realty Co.	Clarendon	1915		150
Canfield Oil Co.	Coraopolis	1897	120,000	370
Pittsburgh Oil Refining Co.	Coraopolis	1892	225,000	1,000
Robinson Oil Corporation	Coraopolis		22,037,000	
Vulcan Oil Refining Co.	Coraopolis			
Pennsylvania Oil Prod. Ref. Co.	Eldred	1913	227,000	300
Emlenton Refining Co.	Emlenton	1891	500,000	500
Bayerson Oil Works	Erie			
United Oil Manufacturing Co.	Erie			
Atlantic Refining Co. (Eclipse)	Franklin	1872		8,000
Foco Oil Co.	Franklin	1917		
Galena-Signal Oil Co.	Franklin	1869		2,000
Franklin Oil Works	Franklin	1877	12,000	300
Freedom Oil Refining Co.	Freedom			1,500
Gulf Refining Co.	Gibson's Point			5,000
Pennsylvania Refining Co.	Karnes City	1901	90,000	40
Starlight Refining Co.	Karnes City	1893	60,000	100
Pure Oil Co.	Marcus Hook	1890		4,500
Sun Oil Co.	Marcus Hook			3,000
Island Petroleum Co.	Neville Island			650
Advance Oil Co.	Oil City	1917	20,000	300
Jas. Berry's Sons	Oil City			
Continental Refining Co.	Oil City	1885	275,000	650
Crystal Oil Works	Oil City	1886	250,000	800
Independent Refining Co.	Oil City	1882	350,000	1,000
Penn-American Oil Co.	Oil City		1,400,000	
Sunrise Oil Co.	Oil City	1917	100,000	
Crew Levick Co.	Petty's Island			
W. H. Daugherty & Son Ref. Co.	Petrolia	1880	125,000	150
Petrolia Refining Co.	Petrolia	1890	20,000	3
Crew Levick Co. Seaboard (Doherty)	Philadelphia			800
Sunlight Oil & Gasoline Works	Philadelphia			
Atlantic Refining Co.	Pittsburgh	1862		3,500
Chippena Refining Co.	Pittsburgh	1917		
A. D. Millers' Sons Co.	Pittsburgh	1862	1,000,000	1,000
Waverly Oil Works	Pittsburgh	1880	600,000	500
Atlantic Refining Co.	Point Breeze	1866		35,000
Coldwater Refining Co.	Raymilton			
Empire Oil Works	Reno	1886	350,000	650
Pan-American Refining Co.	Rouseville	1892	2,000,000	2,500
Crystal Oil Works	Rouseville			
Muir Oil Works	Titusville			
Valvoline Oil Co.	Struthers			
American Oil Works	Titusville	1888	350,000	600
Crew Levick Co. (Messimer plant)	Titusville			660
Crew Levick Co. (Pa. Par. Works)	Titusville			500
Fred G. Clarke Co.	Warren		500,000	
Titusville Oil Works	Titusville	1876	200,000	505
Conewango Refining Co.	Warren	1895	400,000	400
Cornplanter Refining Co.	Warren	1888	1,150,000	2,000
Mutual Refining Co.	Warren	1909	166,800	400
Seneca Oil Works	Warren	1893	350,000	500
Crew Levick Co. (Glade Oil Works)	Warren			500
United Oil Refining Co.	Warren	1902	425,000	385
Superior Oil Works	Warren		175,000	
Warren Refining Co.	Warren	1890		500
Beaver Refining Co.	Washington	1890	115,000	150

REFINERIES IN THE UNITED STATES—Continued.

TENNESSEE

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Lookout Oil & Refining Co	Chattanooga	1917	100,000	1,500
Dixie Refining Co	Memphis	1917	10,000	200
General Ref. & Producing Co	Nashville	1915	15,000	400

TEXAS

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Magnolia Petroleum Co	Beaumont	1902	5,549,000	25,000
United Oil & Refining Co	Beaumont	1903	150,000	2,000
Heming & Gilbert	Near Beaumont	(Bldg.)		
Gotebo Oil & Refining Co	Brownwood	(Bldg.)		1,000
Beaver Valley Oil Refining Co	Cisco			
Burkburnett Refining Co	Burkburnett prop.		30,000	2,000
Central Oil Co	Corsicana	1903	75,000	300
Magnolia Petroleum Co	Corsicana	1898	618,000	2,300
The Texas Co	Dallas	1908		12,000
Oriental Oil Co	Dallas		225,000	
Texas Electra Ref. & Oil Co	Electra prop.	1917	600,000	2,000
Dobert Ligon	El Paso	1917	25,000	200
The Texas Co	Fort Neches	1906		10,000
Gulf Refining Co	Fort Worth	1911	1,500,000	6,000
Magnolia Petroleum Co	Fort Worth	1914	460,000	12,000
Pierce-Fordyce Oil Corp	Fort Worth	1912	3,500,000	6,000
Producers Refining Co. (Empire)	Gainesville	1915	1,000,000	13,000
Hoffman Oil Refining Co	Houston	1916	150,000	800
Petroleum Refining Co	Houston	1916	750,000	3,000
Magnolia Petroleum Co	Houston prop.			
Gulf Refining Co	Houston prop.			
Pierce-Fordyce Oil Corp	Houston prop.			
The Texas Co	Houston prop.			
Humble Oil Co	Houston			
Sinclair Gulf Ref. Corporation	Houston prop.		2,000,000	
Atlantic & Gulf Petroleum Co	Houston Ship Channel prop.			
D'Artois Oil & Refining Co	Houston Ship Channel prop.			
Petroleum Refining Co	Houston Ship Channel prop.			
Sinclair Oil & Refining Co	Houston Ship Channel prop.			
Globe Refining Co	Humble	1916	10,000	155
Wichita Valley Refining Co	Iowa Park	1914	125,000	800
Avis-Wood Refining Co	Jacksboro	1915	150,000	100
Eureka Refining Co	La Porte prop.		15,000	
Mary Owens Oil Co	Moonshine Hill	1917		
Seaboard Oil Refining Co	Orange	1917	150,000	2,000
Oriental Oil Co	Oriental	1912	140,000	1,000
The Texas Co	Port Arthur	1902	45,632,435	28,000
Gulf Refining Co	Port Arthur	1901	25,000,000	55,000
Dixie Oil & Refining Co	San Antonio	1913	240,000	710
International Refining Co	San Antonio prop.		75,000	
Western Oil Refining Co	San Antonio prop.			
H. L. Doherty Syndicate (Houston)	San Jacinto prop.			
Slump Oil Co	Somerset	1915	15,000	60
Pierce-Fordyce Oil Association	Texas City	1911	2,250,000	3,000
Thrall Refining Co	Thrall	1915	24,000	300
Black Diamond Oil Co	Thrall			
Panhandle Refining Co	Wichita Falls	1915	500,000	2,000
Sunshine Hill Oil Co	Wichita Falls			

UTAH

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Basin Oil Refining Co	Basin (Bldg.)	1917		
Utah Refining Co	Salt Lake City	1907	250,000	500
White Rock Oil & Refining Co	Salt Lake City			
Urado Oil Co	Uintah Basin			

VIRGINIA

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Gulf Refining Co	Norfolk (Bldg.)	1917		
Mexican Petroleum Corporation	Norfolk (Bldg.)	1917		
Louisiana Oil Refining Corp	Richmond (Bldg.)	1917		

REFINERIES IN THE UNITED STATES—Continued.

WEST VIRGINIA

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Cabin Creek Refining Co	Cabin Creek Jct.	1917	1,000,000	3,000
Elk Refining Co	Falling Rock	1913	100,000	600
Petroleum Products Co	Jacksonburg			200
Galena-Signal Oil Co	Parkersburg			2,000
Standard Oil Co. of New Jersey	Parkersburg	1893	1,500,000	2,500
Ohio Valley Refining Co	St. Mary's	1913	750,000	1,000
Indian Refining Co	Staunton	1916		

WYOMING

Company	Location	Year Built	Approx. Investm't	Ap. Barrels Crude Daily
Best Oil & Refining Co	Casper prop.			
Mid West Refining Co	Casper	1912	25,000,000	35,000
Utah-Wyoming Oil Refining Co	Casper			
Natrona Pipe Line & Refining Co	Casper		687,767	
Northwestern Refining Co	Casper	(Bldg.)		
Standard Oil Co. of Indiana	Casper	1914	2,000,000	10,000
Kinney Oil & Refining Co	Cheyenne	(Bldg.)		
Northwestern Oil Refining Co	Cowley	1909	120,000	340
Wyatt Oil & Refining Co	Douglas	(Bldg.)		
Colorado-Wyoming Refining Co	Douglas			
Idaho-Wyoming Oil Co	Fossil			
Consumers Oil & Refining Co	Greybull (Bldg.)	1917		3,000
Crystal Creek Petr. & Ref. Co	Greybull prop.			
Greybull Refining Co	Greybull	1915	1,500,000	12,000
Standard Oil Co	Greybull	1916	1,500,000	5,000
Riverton Refining Co	Riverton	(Bldg.)	150,000	1,000
Glenrock Refining Co	Glenrock	(Bldg.)		2,000
Wyoming Refining Co	Glenrock prop.			
Mid West Refining Co	Greybull		25,000,000	
Wyoming Refining Co	Greybull prop.		800,000	
Western Exploration Co	Lander			
Standard Reserve Oil Co	LeRoy		2,221,629	
Wyoming Refining Co	Thermopolis			

Ownership of Tank Cars

(Approximate for December, 1917)

(Taken from "Petroleum" and "Oil and Gas Journal")

Tank Cars Owned by Railroads

Colorado & Southern	14
Delaware River & Union R. R.	211
Denver & Rio Grande Ry	44
East Jersey R. R	120
El Paso & Western	98
Kansas City Southern Ry. Co.	193
Los Angeles & Salt Lake R. R. Co	214
Midland Valley R. R. Co	97
Missouri, Kansas & Texas Ry.	677
Morenci Southern Ry. Co	2
New Orleans, Texas & Mexico R. R.	75
Northwestern Pacific R. R. Co.	34
Oregon-Washington R. R. & Nav. Co.	44
Pacific Electric Ry. Co	29
Pennsylvania R. R. Co	514
Philadelphia & Reading Ry. Co.	20
St. Louis & San Francisco R. R. Co	629
St. Louis, Brownsville & Mexico Ry.	59
St. Louis, Southwestern Ry. Co.	29
San Antonio & Arkansas Pass Ry. Co.	81
Santa Fe Ry. Co	3,178
Santa Fe & Arizona Ry	4
Southern Pacific Ry	2,963
Texas & New Orleans R. R. Co.	459
Trinity & Brazos Valley R. R.	25
Total	9,813

Tank Cars Owned by Oil Industry

Akin Gasoline Co., Tulsa	3
Ajax Gasoline Co., Kansas City.	4
American Oil Products Corp., Erie	3
American Oil Works, Titusville	42
American Refining Co., Tulsa	256
Asphaltum Oil & Refining Co., Los Angeles	3
Associated Oil Co., California	337
Atlantic Refg. Co., Philadelphia.	4
Barkhausen Oil Co., Green Bay, Wis	1
Beaver Refining Co., Washington, Pa	11
J. B. Berry Sons Co., Oil City, Pa	65
F. W. Bird & Sons, E. Walpole, Mass.	3
Blake Oil Co., Liberal Kan	1
Boynton Gasoline Co., Tulsa	4
Brooks Oil Co., Cleveland, O	2
E. A. Bush Co., Palmer, Miss.	3
Butler County Oil Refg. Co., Bruin, Pa	79
Caddo Oil Refg. Co., Shreveport, La	104
Canfield Tank Line, Cleveland.	78
Canfield Refining Co., Yale, Okla	55
Capital Refining Co., Buffalo, N. Y	47
Atwood Refining Co., Oklahoma City	23
Central Refg. Co., Lawrenceville, Ill	293
Chestnut & Smith, Tulsa	12
Cincinnati Oil Works, Cincinnati	1
Clarendon Refg. Co., Clarendon, Pa	16
Cleveland Petroleum Refining Co., Cleveland, O	21
Climax Refining Co., Corsicana, Tex	13
Columbia Oil Co., New York	39
Conewango Refining Co., Warren, Pa	47
Constantin Refining Co., Tulsa.	178
Consumers Mutual Tank Line, Chicago	88
Consumers Refg. Co., Cushing, Okla	379
Continental Oil Co., Denver	8
Continental Refg. Co., Oil City, Pa	50
Continental Refg. Co., Bristow, Okla	40
Cornplanters Refg. Co., Warren, Pa	136
Cosden & Co., Tulsa	1,517
Craig Oil Co., Toledo, O	161
Crew Levick Co., Philadelphia.	200
Crown Gasoline & Oil Co., Pittsburgh	2
Crystal White Refg. Co., Allen, Okla	30
Crystal Oil Works, Oil City, Pa.	34
Crescent Refining Co., Newkirk, Okla	60
Dallas Oil & Refg. Co., Dallas, Tex	20
W. H. Daugherty & Son, Petrolia, Pa	8
Dixie Oil & Refg. Co., San Antonio	33

OWNERSHIP OF TANK CARS—Continued.

Commonwealth Refg. Co., Moran, Kan	24
El Dorado Refg. Co., El Dorado, Kan	82
Economy Oil & Refining Co., Blackwell, Okla	68
Elk Refining Co., Charleston, W. Va	48
Emery Mfg. Co., Bradford, Pa.	90
Emlenton Refining Co., Emlenton, Pa	48
Empire Refineries, Tulsa	860
Empire Oil Works, Oil City, Pa.	980
Ensign Oil Co., Norristown, Pa.	4
D. W. Frauchot Co., Tulsa	12
Freeport-Mex Fuel Oil Corp., New Orleans, La	94
Freedom Oil Works, Freedom, Pa	89
General Refining Co., Tulsa	70
Glenn Pool Tank Line, Kansas City	265
Great Western Oil Co., Cleveland	21
Great Western Oil Refg. Co., Erie, Kan	80
Gulf Refining Co., Pittsburgh.	1,411
Gasoline Corporation, New York	59
General Petroleum Co., Los Angeles	10
Hillman Refining Co., Cushing, Okla	49
High Grade Petroleum Products Co., St. Marys, W. Va.	50
Humboldt Refg. Co., Humboldt, Kan	3
Hutchinson Refg. Co., Hutchinson, Kan	25
Illinois Refining Co., Rock Island, Ill	61
Independent Refg. Co., Oil City, Pa	82
Indiahoma Refg. Co., St. Louis.	450
Indian Refg. Co., Lawrenceville, Ill	1,032
Inland Refg. Co., Tulsa	152
International Oil Works, Ltd., St. Louis	3
International Refg. Co., Tulsa.	418
Interstate Oil Co., Minneapolis, Minn	1
Island Petroleum Co., Pittsburgh	70
Kane Gasoline Co., Kane, Pa.	17
Kanotex Refg. Co., Caney, Kan.	47
Kansas City Oil Co., Kansas City, Kan	5
Kansas Oil Refg. Co., Coffeyville, Kan	94
Kansas City Refg. Co., Kansas City, Kan	171
Kansas Co-operative Refining Co., Chanute, Kan	193
Kendall Refining Co., Bradford, Pa	28
A. Knabb & Co., Marcus Hook, Pa	1
Lawton Refining Co., Lawton, Okla	31
Lake Park Refg. Co., Okmulgee, Okla	111
Lesh Refg. Co., Arkansas City, Kan	34
Leader Oil Co., Casey, Ill	13
Liberty Refg. Co. (Cornplanter Refining Co.), Warren, Pa.	10
Liquified Petroleum Gas Co., Tulsa	8
Louisiana Oil Refining Co., Shreveport	60
Magnolia Petroleum Co., Dallas, Tex	590
Manufacturers Paraffine Co., Chester, Pa	1
Marshall Oil Co., Marshalltown, Ia	7
Mexican Petr. Co., Ltd., New York	145
Mid-Co. Gasoline Co., Tulsa	151
Mid-Continent Oil Refg. Co., East St. Louis, Ill	14
Mid-Continent Refg. Co., Tulsa.	28
Muskogee Refg. Co., Muskogee, Okla	150
Motor Fuel Co., Sapulpa, Okla.	24
Midwest Refg. Co., Denver	22
Miller's Oil Refg. Wks., Allegheny, Pa	44
Miller Petr. Refg. Co., Chanute, Kan	47
Milliken Refg. Co., St. Louis.	70
Mutual Oil Co., Kansas City, Mo	82
Mutual Refg. Co., Ltd., Warren, Pa	18
National Oil Co., New York	24
New Haven Gas Light Co., New Haven, Conn	5
North American Refiners Co., Oklahoma City	226
O. K. Refg. Co., Niotaze, Kan.	161
Oconee Oil Refg. Co., Athens, Ga	10
Okmulgee Products & Refining Co., Okmulgee, Okla	20
Ohio Valley Refg. Co., St. Marys, W. Va	50
Oil Products Corp., New York.	20

OWNERSHIP OF TANK CARS—Continued.

Oklahoma Petroleum & Gasoline Co., Tulsa	41
Oriental Oil Co., Dallas, Tex.	39
Oklahoma Refg. Co., Oklahoma City	93
Ozark Refg. Co., Fort Smith, Ark.	13
Pan-American Refg. Co., Tulsa.	110
Panhandle Refg. Co., Wichita Falls, Tex.	35
Paragon Refg. Co., Toledo, O.	173
Penn.-American Refg. Co., Oil City, Pa.	174
National Refg. Co., Cleveland.	1,004
Pelican Oil Refg. Co., New Orleans	12
Penn. Refg. Co., Oil City, Pa.	6
Pennsylvania & Delaware Oil Co., New York	19
Pennsylvania Oil Products Oil Refg. Co., Eldred, Pa.	35
Petroleum Products Co., Pittsburgh	11
Phoenix Refg. Co., Tulsa	135
Pawnee Refg. Co., Oklahoma	8
Pierce-Fordyce Assn., Dallas, Tex.	403
Pierce Oil Corp., St. Louis	643
Pinal Dome Refg. Co., Santa Maria, Cal.	1
Pittsburgh Oil Refg. Co., Pittsburgh	81
Ponca Lube Oil Co., Ponca City, Okla.	30
Penn. Refining Co., Karns City, Pa.	4
Ponca Refg. Co., Ponca City, Okla.	140
Producers Refg. Co., Oklahoma City	270
Frank Prox Co., Terre Haute, Ind.	5
Prudential Oil Corp., Baltimore, Md.	250
Puente Oil Co., Los Angeles	2
Pure Oil Co., Minneapolis, Minn.	74
Record Oil Refg. Co., New Orleans	35
Richardson Lub. Co., Quincy, Ill.	3
Richfield Oil Co., Los Angeles.	8
Riverside Western Oil Co., Tulsa	225
Roxana Petroleum Corp., Tulsa.	400
Robinson Oil Refg. Co., Robinson, Ill.	9
Rosedale Refg. Co., Rosedale, Kan.	90
Rucker Bros., Everett, Wash.	2
Sapulpa Refg. Co., Sapulpa, Okla.	528
Sarco Petroleum Products Co., Independence, Kan.	183
Seneca Oil Works, Warren, Pa.	67
Sinclair Refg. Co., Chicago	2,150
Levi Smith, Ltd., Clarendon, Pa.	15
Shell Co. of California, San Francisco	50
Southern Oil Corp., Tulsa	108
Standard Oil Co. (Union Tank)	16,608
Stannard, C. A., Emporia, Kan.	14
Sterling Oil & Refg. Co., Wichita	36
Southern Refg. Co., Los Angeles	2
Alden Speare's Sons Co., Boston	6
Superior Oil Works, Ltd., Warren, Pa.	24
The Texas Co., Houston, Tex.	2,975
Titusville Oil Works, Titusville, Pa.	49
Turner Oil Co., Los Angeles	9
Uncle Sam Oil Co., Kansas City, Kan.	51
Union Oil Co. of California, Los Angeles	113
Union Petroleum Co., Philadelphia	105
Union Refg. Co., East St. Louis, Ill.	3
United O. & R. Co., Beaumont, Tex.	5
United Oil Co., Denver	19
United Refg. Co., Warren, Pa.	39
Upson's Oil & Soap Co., Parkersburg, W. Va.	7
Valvoline Oil Works, Ltd., East Butler, Pa.	89
Vulcan Oil Refg. Co., Cleveland, O.	48
Wabash Refg. Co., Robinson, Ill.	88
Wadhams Oil Co., Milwaukee.	5
Warren Oil Co., Warren, Pa.	50
Warren Refg. Co., Warren, Pa.	67
Waverly Oil Co., Pittsburgh	50
Webster Oil & Gas Co., Yale, Okla.	5
Webster Refg. Co., Humboldt, Kan.	4
West Virginia Oil Co., Parkersburg, W. Va.	1
Wichita Independent Oil & Refg. Co., Wichita, Kan.	31
Wilburine Oil Wks., Ltd., Warren, Pa.	54
Wilhoit Refg. Co., Springfield, Mo.	51
White Eagle Petr. Co., Augusta, Kan.	200
Yaryan Rosin & Turpentine Co., Brunswick, Ga.	5
Car Manufacturers	7,969
Total	60,236

Casinghead Gasoline Plants

		Capacity, Gallons
CALIFORNIA		
Fellows Gasoline Co	Fellows, Calif.	
ILLINOIS		
Vacuum Gasoline Co	Bridgeport, Ill.	
Central Refining Co	Lawrenceville, Ill.	
Warner-Caldwell Oil Co	Robinson, Ill.	
Roxana Petroleum Co. of Oklahoma	Wood River, Ill.	
KANSAS		
Paul F. Dahlgren	Elgin, Kan.	
Rhode Island Oil Co	Independence, Kan.	
S. C. Redd	Iola, Kan.	
Hygrade Petroleum & Gasoline Co	Sedan, Kan.	
Sedan Gasoline Co	Sedan, Kan.	
LOUISIANA		
De Soto Gasoline Co	Goss, La.	
Bayou Gasoline Co	Oil City, La.	
Standard Oil Co	Trees City, La.	
Central Oil & Gasoline Co., Inc	Vivian, La.	
OHIO		
Kinkade Oil & Gas Co	Bremen, Ohio	
Marietta Oil Co	Marietta, Ohio	
Jefferson County Oil Co	Rayland, Ohio	
Jefferson Gasoline Co	Rayland, Ohio	
Summerfield Gas Co	Summerfield, Ohio	
Dinsmoor & Co	Washington, Ohio	
John Mildren Sons & Co	Winton, Ohio	
OKLAHOMA		
Mid-Co Gasoline Co	Adair, Okla.	
T. B. Gasoline Co	Alluwe, Okla.	4,000
Hygrade Petroleum & Gasoline Co	Avant, Okla.	1,200
Brighton Gasoline Co	Bald Hill, Okla	1,000
Crystal Gasoline Co	Bald Hill, Okla.	1,500
Mileage Gasoline Co	Bald Hill, Okla.	
Producers Oil Co	Bald Hill, Okla.	
Sinclair Oil & Gasoline Co	Bald Hill, Okla.	
Twin Hill Gasoline Co	Bald Hill, Okla.	600
Akin Gasoline Co	Bartlesville, Okla.	
Mid-Co Petroleum & Gasoline Co	Bartlesville, Okla.	
Moon Gasoline Co	Bartlesville, Okla.	
Frank Phillips	Bartlesville, Okla.	2,500
Wolverine Oil Co	Bartlesville, Okla.	5,000
Corlis Oil Co	Bartlesville, Okla.	
Mileage Gasoline Co	Bartlett, Okla.	
Smith & Swan Gasoline Co	Bartlett, Okla.	600
Chestnut & Smith	Beggs, Okla.	
H. F. Wilcox	Beggs, Okla.	
Paul F. Dahlgren	Big Heart, Okla.	
Whitehall, Donavan, Hayden & Whitehall	Bird Creek, Okla.	
Aiken Gasoline Co	Bixby, Okla.	
Livingston Oil Corporation	Bixby, Okla.	
Okla. Petroleum & Gasoline Co	Bixby, Okla.	
The Three Gasoline Co	Bixby, Okla.	
S. C. Redd	Bixby, Okla.	
H. F. Wilcox	Bixby, Okla.	
Boynton Gasoline Co	Boynton, Okla.	4,000
Carter Oil Co	Boynton, Okla.	3,000
Hays Gasoline Co	Boynton, Okla.	1,100
Sterling Gasoline Co	Boynton, Okla.	

CASINGHEAD GASOLINE PLANTS—Continued.

Arrow Gasoline Co	Broken Arrow, Okla.	500
Consumers Oil & Refining Co	Broken Arrow, Okla.	
Misener Gasoline Co	Broken Arrow, Okla.	500
Okla. Petroleum & Gasoline Co	Broken Arrow, Okla.	
Piedmont Petroleum & Gasoline Co	Broken Arrow, Okla.	1,100
Altena Oil Co	Chelsea, Okla.	2,500
Cinco Oil Co	Chelsea, Okla.	500
Liquefied Petroleum Co	Chelsea, Okla.	5,000
Okla. Petroleum & Gasoline Co	Chelsea, Okla.	
Una Gasoline Co	Chelsea, Okla.	1,200
Henderson Gasoline Co	Childers, Okla.	16,000
Whitehall, Donavan, Hayden & Whitehall	Childers, Okla.	
Gypsy Oil Co	Cleveland, Okla.	
National Products Co	Cleveland, Okla.	
Okla. Petroleum & Gasoline Co	Cleveland, Okla.	
Sinclair Oil & Gasoline Co	Cleveland, Okla.	
B. T. Curley	Coalton, Okla.	200
Tidal Gasoline Co	Coalton, Okla.	
Chestnut & Smith	Cushing, Okla.	
Hillman Refining Co	Cushing, Okla.	500
Magnolia Petroleum Co	Cushing, Okla.	
S. C. Redd	Cushing, Okla.	
C. B. Shafer	Cushing, Okla.	600
Standard Oil Co. of Indiana	Cushing, Okla.	
Roxana Petroleum Co. of Okla	Cushing, Okla.	
Diamond Gasoline Co	Delaware, Okla.	8,000
Aikin Gasoline Co	Dewey, Okla.	2,000
Paul F. Dahlgren	Dewey, Okla.	
Dewey Portland Cement Co	Dewey, Okla.	600
Mid-Co Gasoline Co	Dewey, Okla.	
Barmont Oil Co	Drumright, Okla.	250
Chestnut & Smith	Drumright, Okla.	
Consumers Refining Co	Drumright, Okla.	
Gypsy Oil Co	Drumright, Okla.	
Hesco Gasoline Co	Drumright, Okla.	
Imperial Gasoline Co	Drumright, Okla.	2,000
McMan Gasoline Co	Drumright, Okla.	600
Mid-Co Petroleum & Gasoline Co	Drumright, Okla.	
Ohio Cities Gasoline Co	Drumright, Okla.	3,000
Producers Oil Co	Drumright, Okla.	
Sinclair Oil & Gasoline Co	Drumright, Okla.	
Standard Oil Co. of Indiana	Drumright, Okla.	
Tidal Gasoline Co	Drumright, Okla.	
Okla. Petroleum & Gasoline Co	Glenn Pool, Okla.	
Producers Oil Co	Glenn Pool, Okla.	
Sun Gasoline Co	Glenn Pool, Okla.	
Tulsa Gasoline Co	Glenn Pool, Okla.	600
Victor Gasoline Co	Glenn Pool, Okla.	
Watkins Oil Co	Glenn Pool, Okla.	
Gates Oil Co	Healdton, Okla.	
Magnolia Petroleum Co	Healdton, Okla.	3,000
Superior Oil & Gas Co	Healdton, Okla.	
Mileage Gasoline Co	Haskell, Okla.	
Okla. Petroleum & Gasoline Co	Haywood Spur, Okla.	
Gypsy Oil Co	Jenks, Okla.	
Oil State Gasoline Co	Jenks, Okla.	2,500
Okla. Petroleum & Gasoline Co	Jenks, Okla.	
Totem Gasoline Co	Jenks, Okla.	
Atlas Petroleum Co	Jennings, Okla.	
Crosby & Gillespie	Kiefer, Okla.	9,000
Chestnut & Smith	Kiefer, Okla.	
D. W. Franchot & Co	Kiefer, Okla.	1,000
Glenn Gas Co	Kiefer, Okla.	1,100
Gypsy Oil Co	Kiefer, Okla.	
Victor Gasoline Co	Kelleyville, Okla.	
Heva Gasoline Co	Kelleyville, Okla.	
Lawton Refining Co	Lawton, Okla.	
Continental Gas Compressing Co	Lenapah, Okla.	1,000

CASINGHEAD GASOLINE PLANTS—Continued.

Mileage Gasoline Co	Lost City, Okla.	
Marland Refining Co	Mervin Field, Okla.	3,000
Okla. Petroleum & Gasoline Co	Mohawk, Okla.	
National Products Co	Mounds, Okla.	
Nine Oil & Gas Co	Maud, Okla.	
Chestnut & Smith	Morris, Okla.	
Bradstreet & Co	Muskogee, Okla.	250
De Soto Gasoline Co	Muskogee, Okla.	
Goodwell Oil Co	Muskogee, Okla.	250
Motor Gasoline Co	Muskogee, Okla.	1,100
Persian Oil Co	Muskogee, Okla.	250
Red Demon Gasoline Co	Muskogee, Okla.	800
Sun Gasoline Co	Muskogee, Okla.	
Victor Gasoline Co	Muskogee, Okla.	
Whitfield Sears Oil Co	Muskogee, Okla.	250
Childers Gasoline Co	Nowata, Okla.	500
Tidal Gasoline Co	Nowata, Okla.	
Osage Gasoline Co	Ochelata, Okla.	2,750
Tidal Gasoline Co	Ochelata, Okla.	
A. C. F. Gasoline Co	Oilton, Okla.	2,000
Chieftain Gasoline Co	Oilton, Okla.	
B. B. Jones	Oilton, Okla.	500
Mid-Co Gasoline Co	Oilton, Okla.	
Mid-Co Petroleum & Gasoline Co	Oilton, Okla.	
National Products Co	Oilton, Okla.	
Southland Gas Co	Oilton, Okla.	600
Standard Oil Co. of Indiana	Oilton, Okla.	
Kingwood Oil Co	Okmulgee, Okla.	
Magnolia Petroleum Co	Okmulgee, Okla.	
O. K. Refining Co	Okmulgee, Okla.	
Pine Pool Gasoline Co	Okmulgee, Okla.	600
Southern Gas Co	Okmulgee, Okla.	
Tibbins Gasoline Co	Okmulgee, Okla.	1,000
Mac Betty Gasoline Co	Osage City, Okla.	
H. V. Foster	Osage Junction, Okla.	
Victor Gasoline Co	Peru, Okla.	
Victor Gasoline Co	Preston, Okla.	
Marland Chemical Co	Ponca City, Okla.	
Marland Gasoline Co	Ponca City, Okla.	
Whitehall, Donavan, Hayden & Whitehall	Pumpkin Center, Okla.	
Mileage Gasoline Co	Red Fork, Okla.	
Arthur Oil Co	Sapulpa, Okla.	500
Bluff Gasoline Co	Sapulpa, Okla.	200
Commerce Gasoline Co	Sapulpa, Okla.	1,000
Max Rhea Gasoline Co	Sapulpa, Okla.	600
Richards Gasoline Co	Sapulpa, Okla.	600
Sapulpa Refining Co	Sapulpa, Okla.	
W. G. Skelly	Sapulpa, Okla.	
Cosden Oil & Gas Co	Shamrock, Okla.	8,000
Magnolia Gasoline Co	Shamrock, Okla.	
Sinclair Oil & Gasoline Co	Shamrock, Okla.	
Union Skiatook Gasoline Co	Skiatook, Okla.	
Rotary Gasoline Co	Sperry, Okla.	
Black Hawk Petroleum Co	Stone Bluff, Okla.	
Hygrade Petroleum & Gas Co	Stone Bluff, Okla.	1,200
Sinclair Oil & Refining Co	Stone Bluff, Okla.	
Okla. Petroleum & Gasoline Co	Standard Spur, Okla.	
O. G. Bantley	Tamaha, Okla.	
The Dallas Co	Tulsa, Okla.	
Pulaski Refining Co	Turkey Mountain, Okla.	700
Silver Gasoline Co	Vega, Okla.	
De Soto Gasoline Co	Wann, Okla.	3,000
Mid-Co Gasoline Co	Wann, Okla.	
Okla. Petroleum & Gasoline Co	Wateva, Okla.	
Chestnut & Fitzgerald	Watkins, Okla.	600
Eagle Gasoline Co	Watkins, Okla.	1,100
Monarch Gasoline Co	Watkins, Okla.	1,100

CASINGHEAD GASOLINE PLANTS—Continued.

PENNSYLVANIA

Bradford Oil & Gasoline Co.	Bell's Camp, Pa.
Pennsylvania Gasoline Co.	Bradford, Pa.
B. B. Stroud Co.	Bradford, Pa.
W. H. Miller.	Chicora, Pa.
Clarendon Gasoline Co.	Clarendon, Pa.
Clarendon Refining Co.	Clarendon, Pa.
D. and C. P. McKee.	Clintonville, Pa.
Jane Oil Co.	Emlenton, Pa.
Gilmore Gasoline Co.	Gilmore, Pa.
Kane Gasoline Co.	Kane, Pa.
C. J. Ritzert Co.	St. Joe, Pa.
Henry Farm Oil Co.	Warren, Pa.
Gilmore Gasoline Co.	Wafferty Hollow, Pa.
Wayne Naptha Co.	Waynesburg, Pa.

TEXAS

Humble Oil & Refining Co.	Burkburnett, Tex.
Schulz Gasoline Co.	Burkburnett, Tex.
Forest Oil Co.	Electra, Tex.
Forest Oil Co.	Iowa Park, Tex.

WEST VIRGINIA

Imperial Oil & Gas Products Co.	Hannahdale, W. Va.
Jas. B. Berry's Sons Co.	Sisterville, W. Va.
Consumers Refining Co.	Waverly, W. Va.
Laughner & Fleming.	Wellsburgh, W. Va.

Principal Pipelines

Pipeline	Mileage	From / To		Capacity, barrels
Alluwe Pipeline Co.	40	From	Alluwe Dist. Okla.	
(Kas. Oil Ref. Co.)		To	Coffeyville, Kas.	2,500
Amalgamated Oil Co.	70	From	Salt Lake Dist. Cal.	
		To	Los Angeles, Cal.	9,000
American Petroleum Co.	20	From	Humble	
		To	E. Houston, Tex.	
Associated Oil Co.	105	From	Coalinga Dist. Cal.	
		To	Monterey, Cal.	15,000
Associated Oil Co.	60	From	Santa Barbara Co., Cal.	
		To	Gaviota, Cal.	23,000
Arkansas City Pipeline Co.		From	Blackwell	
		To	Arkansas City, Kas.	
Associated Pipeline Co.	281	From	Kern River Dist. Cal.	
		To	Port Costa, Cal.	13,000
Associated Pipeline Co.	278	From	Sunset Dist. Cal.	
		To	Port Costa, Cal.	26,000
Buckeye Pipeline Co., Lima Division		From	Ohio-Ind. state boundary	
	700	To	Ohio-Penn. state bound.	75,000
Bessemer Pipeline.		From	Titusville, Pa.,	
		To	W. Pa.	
Buckeye Pipeline Co., Macksburg Division	350	From	Eastern Ohio	
		To	Ohio-Penn. and Ohio-W. Va. boundary	10,000
Colive Oil Co.		From	Healdton	
		To	Ardmore	
Crown Pipeline Co.	58	From	Okmulgee	
		To	Muskogee	
Cosden & Co.		From	adjacent wells	
		To	Bigheart, Okla.	500
Cosden Pipeline Co.		From	Various Okla. oil dist.	
		To	West Tulsa, Okla.	30,000
Crescent Pipeline Co.	315	From	Greggs, Pa.	
		To	Marcus Hook, Pa.	5,600
Cumberland Pipeline Co.	475	From	Southeastern Kentucky	
		To	Kentucky-W. Va. bound	10,000
Emery Pipeline Co.	480	From	Adjacent oil dist.	
		To	Bradford, Pa.	1,000
Empire Pipeline Co.	85	From	Eldorado and Augusta, Kas.	
		To	Ponca City, Okla.	
Empire Pipeline Co.	67	From	Ponca City, Okla.	
		To	Norfolk, Okla.	
Empire Pipeline Co.	70	From	Northern Oklahoma	
		To	Independence, Kas.	
Empire Pipeline Co.	55	From	Healdton, Okla.	(Total)
		To	Gainesville, Texas	35,000
Eureka Pipeline Co.	4,300	From	Kentucky-W. Va. bound. and Ohio W. Va. bound.	
		To	W. Va.-Pa. boundary	65,000
Franklin Pipe Co.		From	Adjacent fields	
		To	Franklin, Pa.	150
General Pipeline Co.	156	From	Midway Dist. Cal.	
		To	Los Angeles, Cal.	25,000
General Pipeline Co.	52	From	Liebere, Cal.	
		To	Mojave, Cal.	5,000
Gulf Pipeline Co.	458	From	Tex.-Okla. State Line	
		To	Port Arthur, Texas	28,000
Gulf Pipeline Co.	76	From	Batson, Texas	5,000
		To	Sour Lake and Houston	14,000
Gulf Pipeline Co.	117	From	La.-Tex. State Line	4,000
		To	Lufkin Station, Texas	9,600
Gulf Pipeline Co.	124	From	Saltillo Station, Texas	
		To	Fort Worth, Texas	7,000
Gulf Pipeline Co. of Okla.	275	From	Bartlesville, Okla.	
		To	Okla.-Tex. boundary	25,000
Gulf Refining Co. of La.	21	From	Mansfield, La.	
		To	La.-Texas boundary	10,000
Hale Petroleum Co.	20	From	Eldorado, Kas.	
		To	Wichita, Kas.	7,500

PRINCIPAL PIPELINES—Continued.

Pipeline	Mileage		From / To	Capacity, barrels
Illinois Pipeline Co.	1,300	From	Alton, Ill.	
		To	Centerbridge, Pa.	60,000
Illinois Pipeline Co.	25	From	Grass Creek, Wyo.	
		To	Chatham, Wyo.	
Illinois Pipeline Co.	15	From	Elk Basin, Wyo.	
		To	Frannie, Wyo.	
Illinois Pipeline Co.	20	From	Big Muddy, Wyo.	
		To	Casper, Wyo.	20,000
Imperial Pipeline Co., Ltd.	155	From	Sarnia, Ont.	
		To	Cygnet, O.	8-inch
Indiana Pipeline Co.	800	From	Griffith, Ind.	
		To	Indiana-Ohio bound.	110,000
Magnolia Petroleum Co.	569	From	Electra, Tex.	
		To	Sabine, Texas	60,000
Magnolia Petroleum Co.	137	From	Healdton, Okla.	
		To	Fort Worth, Tex.	60,000
Magnolia Petroleum Co.	150	From	Cushing Dis., Okla.	
		To	Addington, Okla.	50,000
Maryland Pipeline Co.		From	Kay County, Okla.	
		To	Ponca City, Okla.	
Midwest Refining Co.	90	From	Salt Creek Dist., Wyo.	
		To	Casper, Wyo.	13,000
National Pipeline Co.	60	From	Oil fields in Wood Co., O.	
		To	Findlay, Ohio	1,000
National Pipeline Co.	110	From	Oil fields in S. E. Ohio	
		To	Marietta, Ohio	500
National Transit Co.	205	From	Nedska, Penn.	
		To	New York-Pa. boundary	
National Transit Co.	175	From	Colegrave, Pa.	
		To	Milway, Pa.	
National Transit Co.	35	From	Milway, Pa.	
		To	Fawn Grove, Pa.	75,000
National Transit Co.	70	From	Milway, Pa.	
		To	Point Breeze, Pa.	
National Transit Co.	70	From	Milway, Pa.	
		To	Centerbridge, Pa.	
Natrona Pipeline Co.	90	From	Salt Creek, Wyo.	
		To	Casper, Wyo.	6-inch
New York Transit Co.	130	From	Pa.-New York boundary	
		To	Buffalo, N. Y.	55,000
New York Transit Co.	1,100	From	Olean, N. Y.	
		To	Bayonne, N. J., and Long Island, N. Y.	
Northern Pipe Co.	525	From	Pa.-Ohio boundary	
		To	Pa.-N. Y. boundary	60,000
Oklahoma Pipeline Co.	229	From	Creek County, Okla.	
		To	McCurtain, Okla.	35,000
Paragon Refining Co.	237	From	Sandusky County, Ohio	
		To	Toledo, Ohio	4,000
Prairie Pipeline Co.	701	From	Cushing Dist., Okla .	
		To	Humboldt, Kas.	100,000
Prairie Pipeline Co.	1,820	From	Humboldt, Kas.	
		To	Sugar Creek, Mo. and Wood River, Ill.	94,000
Prairie Pipeline Co.	90	From	McCurtain, Okla.	
		To	Ida, La.	31,000
Prairie Pipeline Co.	85	From	Eldorado-Augusta Kas.	
		To	Neodesha, Kas.	
Pierce Pipeline Co.	135	From	Healdton, Okla.	
		To	Fort Worth, Texas	
Producers' & Refiners' Pipe Line Co.	210	From	Watertown, Ohio	
		To	Titusville, Pa.	9,000
Producers' Transportation Co.	41	From	Coalinga Dist., Cal.	
		To	Junction, Cal.	15,000
Producers' Transportation Co.	50	From	Sunset Dist., Cal.	
		To	Junction, Cal.	20,000
Producers' Transportation Co.	39	From	Kern River Dist., Cal.	
		To	McKittrick, Cal.	

PRINCIPAL PIPELINES—Continued.

Pipeline	Mileage		From To	Capacity, barrels
Producers' Transportation Co.	13	From	Lost Hills Dist., Cal.	
		To	Trunk Line, Cal.	
Producers' Transportation Co.	3	From	Belridge Dist., Cal.	
		To	Trunk Line, Cal.	
Producers' Transportation Co.	74	From	Junction, Cal.	
		To	Port San Luis, Cal.	30,000
Pure Oil Pipeline Co.........	250	From	Morgantown, W. Va.	
		To	Marcus Hook, Pa.	10,000
Rio Bravo Oil Co...............	13	From	Saratoga, Texas	
		To	Sour Lake, Texas	1,500
Sinclair-Cudahy Pipeline Co...	750	From	Cushing Dist., Okla.	
		To	Kansas City and Chicago	
Sinclair-Cudahy Pipeline Co...	70	From	Cushing Dist., Okla.	
		To	Coffeyville, Kas.	
Sinclair-Cudahy Pipeline Co...	340	From	Branches and lateral in Okla. and Kansas	50,000
Southern Pipeline Co...........	1,130	From	Pa.-W. Va. boundary	
		To	Philadelphia, Pa.	51,000
Southwestern Penn. Pipelines..	1,650	From	Operates exclusively in Southwestern Pa.	45,000
Standard Oil Co. Cal..........	281	From	Kern River Dist., Cal.	
		To	Richmond, Cal.	65,000
Standard Oil Co. Cal...........	32	From	Midway Dist., Cal.	
		To	Bakersfield, Cal.	65,000
Standard Oil Co. Cal...........	29	From	Coalinga Dist., Cal.	
		To	Mendota, Cal.	28,000
Standard Oil Co. Cal.......... .	21	From	Lost Hills Dist., Cal.	
		To	Pond, Cal.	20,000
Standard Oil Co. Cal...........	24	From	Northan Dist., Cal.	
		To	El Segundo, Cal.	27,000
Standard Oil Co. Cal...........	45	From	Newhall Dist., Cal.	
		To	Ventura, Cal.	1,400
Standard Oil Co. Cal...........	32	From	Santa Mina Dist., Cal.	
		To	Port Hartford, Cal.	20,000
Standard Oil Co. of La.........	522	From	Ida, Louisiana	
		To	Baton Rouge, La.	35,000
Sun Co.........................	250	From	Seneca and Wood Co., O.	
		To	Toledo, Ohio	1,000
Sun Pipeline Co...............	100	From	Humble, Texas (also Yale, Okla.)	
		To	Sabine Pass, Texas	21,000
Texas Co. (main lines)........	742	From	Bartlesville, Okla.	
		To	Port Arthur, Texas	20,000
Texas Co. (main lines)........	160	From	Electra, Texas	
		To	West Dallas, Texas	17,000
Texas Co. (main lines)........	253	From	Vivian, La.	
		To	Port Arthur, Texas	20,000
Texas Co. (main lines)........	96	From	Evangeline, Texas	
		To	Garrison, Texas	9,600
Texas Co. (main lines)........	60	From	Healdton, Okla.	
		To	Sherman, Texas	12,000
Texas Co. (laterals)...........	222	From	In Okla. and Texas	
		To		
Tidewater Pipe Co. (main line)	830	From	Stoy, Ill.	
		To	Bayonne, N. J.	11,000
Tidewater Pipe Co. (laterals).	1,929	In Pennsylvania, N. Y., Ill. and Ind.		
Union Oil Co..................	65	From	Orcutt, Cal.	
		To	Port San Luis, Cal.	
Union Oil Co..................	43	Local lines in Ventura County, Cal.		
Union Oil Co..................	51	Local lines in Los Angeles, Orange County fields, Cal.		
Valley Pipeline Co.............	170	From	Coalinga Dist., Cal.	
		To	San Francisco Bay	25,000
Wilburine Pipeline Co.........	125	From	Shannopin, Pa.	
		To	Warren, Pa.	5,000
Yarhola Pipeline Co...........	135	From	Healdton, Okla.	
		To	Cushing, Okla.	9,000
Yarhola Pipeline Co...........	400	From	Cushing, Okla.	
		To	St. Louis, Mo. and Wood River, Ill.	36,000

Important Oil Companies Operating in Oklahoma, California, Wyoming, Kansas and Texas

Company.	Affiliations.
Amalgamated Oil Co.	The Amalgamated Oil Co., the Arcturus Oil Co. and the Salt Lake Oil Co. are affiliated and controlled by the Associated Oil Co., which in turn is controlled by the Kern Trading & Oil Co., the producing company of the Southern Pacific Railroad.
Associated Oil Co.	Controlled by the Kern Trading & Oil Co.
Carter Oil Co.	Owned by Standard Oil Co. of New Jersey.
Cosden Oil & Gas Co.	Presumably independent. Some of its affiliated companies are Cosden & Co., Cosden Pipeline Co., Glenn Pool Pipeline Co., Union Petroleum Co., Pen-Mar Oil Co.
Empire Gas & Fuel Co.	Afilliated with the Empire Refineries, Inc. Is an independent concern.
General Petroleum Corporation	An independent company.
Gulf Production Co.	Owned by the Gulf Oil Corporation which is considered an independent.
Gypsy Oil Co.	Held by Gulf Oil Corporation, an independent.
Humble Oil & Refining Co.	An independent organization.
Invincible Oil Co.	This is an independent, so far as known.
Kern Trading & Oil Co.	A producing company of the Southern Pacific Railroad.
McMan Oil Co.	Sold a controlling interest to the Magnolia Petroleum Co. several months ago.
Magnolia Petroleum Co.	Commonly known as a Standard Oil Co.
Monitor Oil & Gas Co.	An independent company so far as generally known.
Oil Cities Gas Co.	An independent organization. Has a number of subsidiaries, some of which are the Ardmore Refining Co., International Refining Co., Pure Oil Co., Cornplanter Refining Co. and Quaker Oil & Gas Co.
Ohio Oil Co.	One of the Standard Oil group.
Pan-American Petroleum & Transport Co.	One of the Doheny interest, presumably with no Standard Oil relations.
Prairie Oil & Gas Co.	One of the Standard Oil group and was a subsidiary of Standard Oil of New Jersey until it was separated therefrom by dissolution decree of the U. S. Supreme Court in 1911.
Producers Oil Co.	Controlled by the Texas Co., 20% of the stock of which the Federal Trade Commission states is owned by the stockholders of different Standard Oil companies.
Quaker Oil & Gas Co.	Originally controlled by Pure Oil Co. Now controlled by Ohio Cities Gas Co.
Republic Production Co.	A newly organized company in Texas and is believed to be independent.
Roxana Petroleum Co.	A subsidiary of the Royal Dutch Shell group.
Shell Co. of California	A subsidiary of the Royal Dutch Shell group.
Silurian Oil Co.	An independent organization so far as known.
Sinclair Oil & Gas Co.	An independent company which has acquired a large number of smaller producers. The Sinclair Oil and Sinclair Gulf are co-interests.
Standard Oil Co. (California)	One of the Standard Oil group.
Sun Co.	A close corporation and its connection to other companies is not generally known.
Tidal Oil Co.	Principally owned by Tidewater Oil Co., some of the stock of which is held by stockholders in the Standard Oil Co., though presumably independent.
Wyoming Oil Fields Co.	Supposedly independent.

Losses in the Storage of Crude Petroleum

The principal losses in the storage of crude petroleum are due to evaporation, to fire and to seepage.

Oils having the greatest loss are the crude oils containing the most gasoline, since they are the most volatile, most readily form explosive and inflammable mixtures and due to their low viscosity most readily flow through walls of loose texture.

The loss from evaporation is greater the larger the amount of gasoline. The loss also depends upon the temperatures of storage, upon the amount of surface exposed to the atmospheric circulation. If the tank or container is perfectly gas tight, then there will be no loss by evaporation.

There are three general types of storage now in use in the Mid Continent fields, the earthen reservoir, the steel tank with wooden roof and the steel tank with a steel gas tight roof.

The 55,000 and 35,000 barrel steel tanks are the usual sizes. Altogether there are more than 3,000 of these large steel tanks in use in the Mid Continent field.

The earthen storage is extremely wasteful from both seepage and evaporation. Petroleum standing in this type of reservoir has been known to shrink 40% in volume in two or three weeks. The shrinkage in value is, of course, much greater, as the portion lost by evaporation is the best of the gasoline.

The following losses by evaporation took place in steel tanks with no seepage, with wooden roof covered with paper and tarred and apparently tight. The oil was of 40°Be' gravity and the tanks were of a diameter of 114½ feet.

Capacity	Loss in gauge	Actual loss	Period	% Loss
55,000 bbls.	1 ft. 1¾ in.	2101 bbls.	5 mos.	4.2%
55,000 bbls.	1 ft. 2⅝ in.	2235 bbls.	4½ mos.	4.6%
55,000 bbls.	11⅛ inches	1700 bbls.	3½ mos.	3.4%
55,000 bbls.	1 ft. ½ in.	1910 bbls.	3¼ mos.	3.8%

The above figures indicate that there might be a loss of 1% per month of storage in wooden roof steel tanks and this might amount to as much as 6,000 barrels per year per tank.

It has been claimed that oil stored in white tanks is subjected to 1 to 1½% less evaporation than in red tanks and 2½% less evaporation than in black tanks.

Various types of insulation have been used with success.

A typical storage temperature for the Mid Continent field for oil stored above ground would be 80°F. A typical temperature of the ground for a submerged tank would be 60°F., which would more nearly approach the storage temperature of the air for the whole year.

If tanks could be successfully and cheaply built in the ground, they would have the advantage of almost perfect insulation from out-

side heat, and the oil would be stored at practically the temperature at which it comes from the ground. For this submerged type of tank, concrete construction would be proper if capable of perfect construction. It should be monolithic, well reinforced and lined with a coating impervious to water and gasoline.

Next in quantity after the evaporation losses in the storage of crude oil is the loss due to fire. Loss from fire in the oil field storage in the year 1916 amounted to about $4,000,000.

The causes of fires are electrical discharges or open flames in the presence of an inflammable or explosive mixture of gasoline and air. The amount of gasoline vapor in air necessary for an explosive mixture is within the limits if 1½% and 5% by weight. Less than the lower limit or more than the upper limit will not inflame. In an open tank if the amount at the surface of the oil exceeds 1½% there is at some point an explosive mixture, and an igniting temperature of 900°F. or over will cause it to take fire. In a perfectly tight tank, with gasoline vapor in excess of the upper limit for an explosive mixture, there will be no fire unless the roof of the tank is open at some point.

The ingress of a flame through an opening may be prevented in the same way that the flame in the Davy miner's lamp is prevented from passing outward. This operates by having some metal screen or other material cool the flame and prevent it being propagated into the tank. This will not prevent ignition from an electrostatic discharge in the vapor space of the tank.

Methods for prevention of fires of oil in storage are as follows:

1st. Means of preventing the passage of the spark in a portion of the unfilled face of the tank.

2nd. The maintenance of a mixture in the unfilled portion of the tank which is not an explosive mixture.

3rd. A tank so placed and constructed that the cooling effect of the walls will tend to smother the flames and the ingress of air will be so arranged that the fire is not readily fed.

4th. A means for quickly eradicating the fire after it is ignited.

Several more or less successful methods for extinction of oil tank fires have been in use. The best involves the use of mixtures of sodium bicarbonate and sulphuric acid which produce sufficient carbon dioxide to smother the flame. If some sort of saponifying agent is used the carbon dioxide will make a froth which will float on the surface of the oil and is very effective in extinguishing the flame.

The application of steam is very effective, but in the storage of a very large amount of oil the steam is not always available when needed and at the point where needed.

Gasoline

Gasoline as now found on the market is a mixture of petroleum hydrocarbons, having an initial boiling point of from 80°F to 160°F, an end boiling point of from 368°F to 450°F, gravity of 56 to 61°Be', a sweet to oily aroma and a water white color.

The particular hydrocarbons composing it belong to a general group known as the paraffins. Other types of hydrocarbons are occasionally present in a very small amount. These are known as olefins and as benzenes. The olefins are removed by a thorough treatment with sulphuric acid, but the benzenes remain if originally present.

Ordinary gasoline made by the natural distillation of Mid Continent crude oil will contain several or all of the following substances:

Name	Boiling Point	Specific Gravity	Baume' Gravity
1. Pentane	97° F	0.630	92.2°
2. Hexane	156° F	0.670	78.9°
3. Heptane	209° F	0.697	70.9°
4. Octane	258° F	0.718	65.0°
5. Nonane	302° F	0.740	59.2°
6. Decane	343° F	0.750	56.7°
7. Undecane	383° F	0.760	54.2°

The following aromatic compounds are produced by pyrogenic decomposition of heavy hydrocarbons and rarely exist naturally in crude petroleum.

They are produced by the cracking of oil in the vapor phase and at high temperatures and occur in artificial, or what has been called "synthetic" gasoline.

Name		Boiling Point	Specific Gravity	Baume' Gravity
Benzol	(C_6H_6)	176°F	0.880	29.1°
Toluol	($C_6H_5CH_3$)	232°F	0.872	30.6°
Xylene	($C_6H_4(CH_3)_2$	291°F	0.882	28.7°

A small amount of these hydrocarbons in commercial gasoline very materially affects the gravity.

The character of gasoline is governed almost entirely by its use for automobiles. It is also used to some extent for stove gasoline and for cleaning purposes, in which case it has a lower end point and a higher Baume' gravity.

Gasoline is commonly blended and originates from one or more of the following sources:

1. The natural product distilled from crude oil. This constitutes about 82.5% of the total on the market. (1917-18.)

2. As a condensate from natural gas and known as casinghead gasoline. This constitutes about 5% of all gasoline and is always incorporated with heavy hydrocarbons such as naphtha, or with gasoline distilled from a heavy crude, or with gasoline made by cracking.

3. The light hydrocarbons produced by the pyrogenic decomposition of heavy petroleum residua. This constitutes about 12.5% of

the market gasoline and tends to have a considerable amount of aromatic compounds.

The most desirable properties of gasoline are low end point and a low initial boiling point, the usual refiner's practice being to call everything gasoline which distills up to a temperature of 410°F. This practice in a light crude gives a 58°Be' product, although in the unusually light crudes a 61° product is obtained and in heavy crudes a gravity as low as 54° may be obtained. This heavy gasoline must be blended to make it satisfactory for ordinary market purposes.

Page 105 shows the relation of the boiling point to the specific gravity of ordinary market gasoline. Gasolines containing considerable olefins, aromatics or naphthenes have a higher relation of specific gravity to boiling point than do gasolines composed entirely of paraffin hydrocarbons.

Page 53 shows the relation of the boiling temperature to the percentage distilled over in ordinary commercial gasoline. These curves show that the gravity alone is not a good measure of the quality of of a gasoline. For example, a 58° gravity gasoline in one case has an initial boiling point of less than 100°F and in another case has an initial boiling point of 190°F. A naphtha blended with casinghead will have a very high gravity test, but will show a very low initial boiling point and a very high end point.

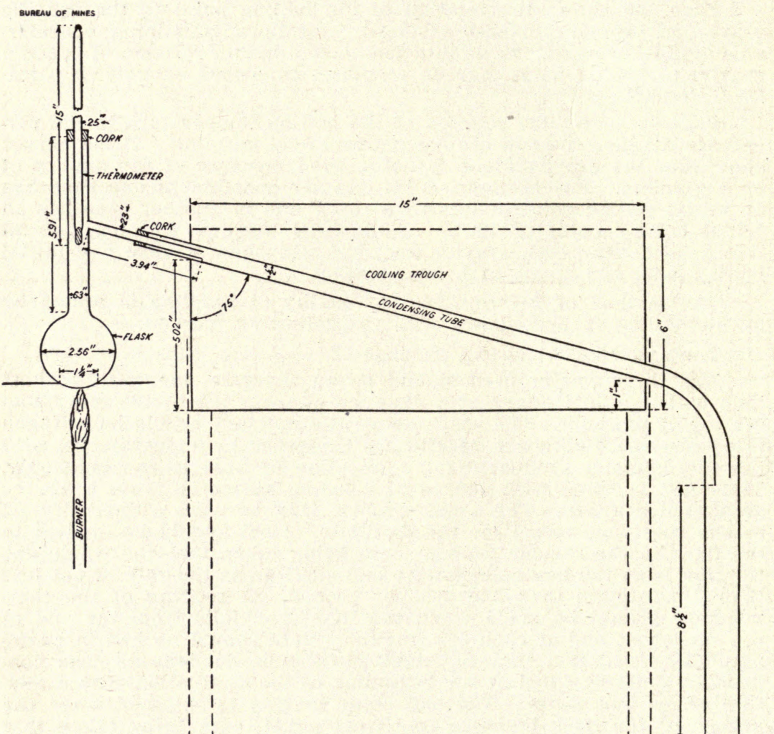
The method of determining the quality of gasoline is ordinarily by distillation in accordance with the following method.

The apparatus is shown on page 52.

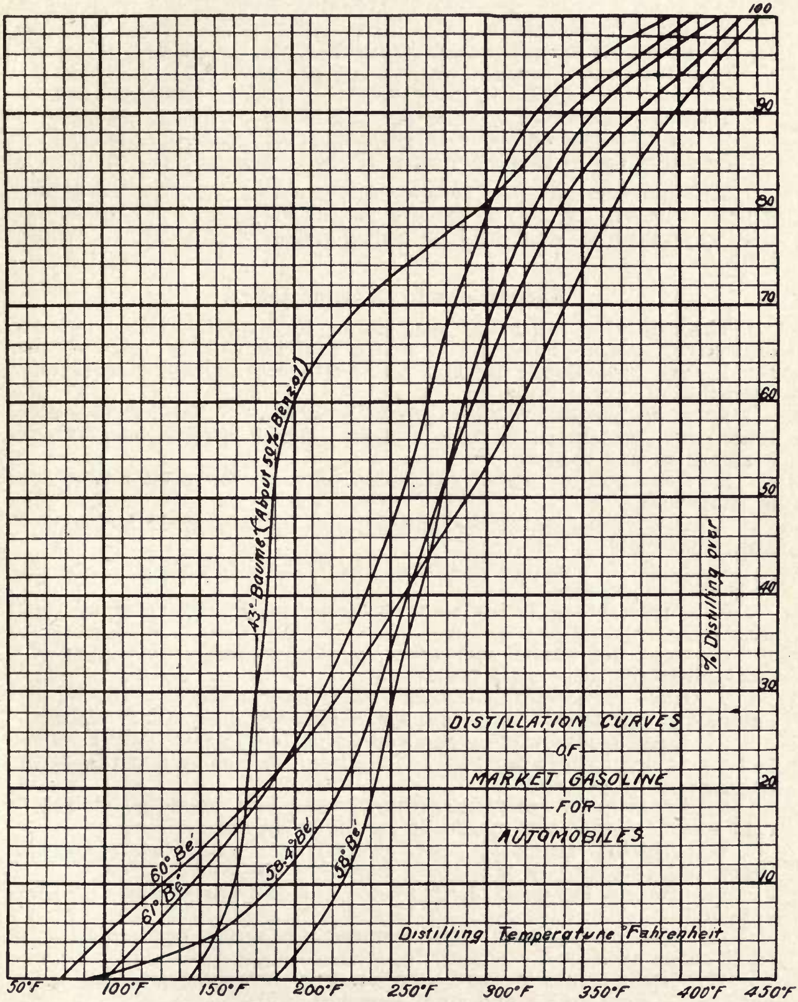
The thermometer used should be an accurate one, with a short bulb with the 50°F mark at a distance of from 100 to 120 mm. from the top of the bulb. The space above the mercury should be nitrogen filled and the distillation results are expressed in temperatures, with the thermometer graduated for application of heat to the bulb only. The flask is filled with 100 cc of gasoline measured from a 100 cc graduated cylinder. The same cylinder may be used without drying, as the receiving vessel for the distillate. Heat should be applied to the flask in the regular manner, care being taken that the whole distillation from the beginning to the end shall be at the rate of not less than 2 nor more than 3 drops per second. A reading of the thermometer should be made when the first drop falls from the end of the condenser and at each 5% fraction. Care should be had in beginning the distillation that the light gasoline is condensed. The condenser should be filled at the beginning of the distillation with a mixture of ice and water. The end point reading is obtained when the bottom of the flask becomes free from liquid, care being taken that the flame does not strike any portion of the flask except the circular area at the bottom.

REQUIREMENTS FOR AEROPLANE GASOLINE.

Required amount estimated	3,500,000 bbls.
Specific Gravity	.720=64.5°Be'
End Point	below 150°C=302°F
Distilling at 240°F (115°C)	over 87.5%
Distilling at 212°F (100°C)	over 65.0%



APPARATUS FOR DISTILLATION TESTS OF GASOLINE.


DISTILLATION CURVES
OF
MARKET GASOLINE
FOR
AUTOMOBILES
43° Baume (About 50% Benzol)
60° Bé
61° Bé
58.4° Bé
58° Bé
% Distilling over
Distilling Temperature °Fahrenheit
50°F
100°F
150°F
200°F
250°F
300°F
350°F
400°F
450°F
10
20
30
40
50
60
70
80
90
100

POSSIBLE SAVINGS IN GASOLINE.

The Bureau of Mines estimates that the following savings can be effected daily:

	Gallons
Tank wagon losses	7,200
Leaky carburetors, average 1/17th of a pint per car	31,400
Poorly adjusted carburetors, ½-pint per car	240,000
Motors running idle, ¼-pint per car	150,000
Wasted in garages, 10 pints per day	67,000
Saved by using kerosene in garages	108,000
Needless use of passenger cars, 1¾ pints per car	897,400

This makes a total of 1,500,000 gallons a day or 561,000,000 gallons a year, whereas our war needs are 350,000,000 gallons a year, or less than two-thirds of what may be considered as wasted at the present time.

Suggestions to Gasoline Users.

The following important suggestions for avoiding waste will not only save gasoline, but users of motor vehicles will be benefited personally and individually through more efficient and more economical operation of cars:

1. Store gasoline in underground steel tanks. Use wheeled steel tanks with measuring pump and hose. They prevent loss by fire, evaporation and spilling.
2. Don't spill or expose gasoline to air—it evaporates rapidly and is dangerous.
3. Don't use gasoline for cleaning and washing—use kerosene or other materials to cut grease.
4. Stop all gasoline leakages. Form habit of shutting off gas at tank or feed pipe.
5. Adjust brake bands so they do not drag. See that all bearings run freely.
6. Don't let engine run when car is standing. It is good for starter battery to be used frequently.
7. Have carburetors adjusted at service stations of carburetor or automobile companies—they will make adjustments without charge.
8. Keep needle valve clean and adjust carburetor (while engine is hot) to use as lean mixture as possible. A rich mixture fouls the engine and is wasteful.
9. Pre-heat air entering carburetor and keep radiator covered in cold weather—this will insure better vaporization.
10. See that spark is timed correctly with engine and drive with spark full advanced—a late spark increases gas consumption.
11. Have a hot spark, keep plugs clean and spark points properly adjusted.
12. Avoid high speed. The average car is most economical at 15 to 25 miles an hour.
13. Don't accelerate and stop quickly—it wastes gas and wears out tires. Stop engine and coast long hills.
14. Cut down aimless and needless use of cars. Do a number of errands in one trip.
15. Know your mileage per gallon. Fill tank full and divide odometer mileage by gallons consumed.

Kerosene (Coal Oil)

Kerosene is that fraction of crude oil which distills at from 302 to 572°F (150-300°C) and contains no gasoline or residuum. Its flash point is always greater than 100°F and usually greater than 125°F. Its color may be standard white, prime white, superfine white or water white. The specific gravity ranges from 38 to 45°Be'; 41°Be' is typical of kerosene now sold for general illuminating purposes.

Sulphur is fairly completely removed from kerosene, being less than 0.03%. Kerosene consists chiefly of the paraffin series, nonane, decane, undecane, duodecane, tridecane, tetradecane, pentadecane, hexadecane and heptadecane. It also contains naphthenes and aromatic compounds if made from asphaltic or semiparaffin base petroleums. Good kerosene should have the following properties:

1. Specific gravity shall be between 0.760-0.860 (54.2°Be'-32.8°Be).
2. Flash point should be over 100°F by closed tester.
3. Color shall be water-white with no turbidity.
4. Cold test shall be below 10°F.
5. End point shall be below 600°F.
6. Sulphur shall be below 0.03%.
7. Acid shall be absent.
8. It should not lose more than 1% on treatment with 66° sulphuric acid.

Gas Oil

Gas Oil is used for making gas and for carbureting gas.

The following is typical of its properties. It is a product of destructive distillation and contains a large amount of olefins:

Specific Gravity		0.843=36.1°Be
Flash point		90°C
Burning point		116°C
Distillation test:		
	0°C-150°C	0.0%
	150°C-300°C	44.0%
	300°C up	55.3%
	Coke	0.7%

Explosion Engine Oils (Diesel Engines)

Explosion Engine Oils should have the following properties:

1. Specific Gravity shall be below .920.
2. Water shall be below 1%.
3. Flash point shall be between 60°C-100°C.
4. Volatility shall be 80% or more at 350°C in Engler Flask.
5. Cold test shall be below 32°F.
6. Coke shall be less than 3%.
7. Sulphur shall be below 0.75%.
8. Solubility in xylene shall be more than 99.5%.
9. Acids and alkalies shall be absent.

Straw Oil (For Benzol Absorption)

1. Specific Gravity shall be not over 0.875 at 60°F.
2. Viscosity shall be not over 185 (Saybolt Universal).
3. Steam distillation using 500cc of oil at temperature of 100°C (212°F) and 500 grams of steam shall yield not over 10cc of distillate.
4. Oil should not emulsify with water in test No. 7 as indicated by the absence of an emulsified band at junction of water and oil after 15 minutes.
5. With fire distillation the boiling point should be above 285°C.
6. It should not jelly or solidify above 0°C (32°F).
7. Emulsification test, 100cc shaken vigorously in a stoppered 200cc cylinder with 100cc of water, the separation should take place as quickly as possible. 95% at least should separate in 10 minutes.
8. Olefins: Should not lose more than 10% in volume when washed with 2.5 times its volume of a mixture of 2 parts of 93% H_2SO_4 and 1 part of fuming sulphuric acid containing about 25% free SO_3.

REQUIREMENTS FOR ROAD OIL.

Specifications for oil for oiling roads vary greatly, but the following is typical:

Appearance	Perfectly homogeneous
Water	None
Foam test (250°F)	Negative
Specific Gravity	.900-1.010
Flash point	over 80°C (176°F)
Specific Viscosity $\frac{\text{Saybolt}}{30}$ at 212°F	15-30
Float test	over 75 seconds
Loss on heating 20 grams at 325°F	below 15%
Total Bitumen	over 99.5%
Solubility in Petroleum Ether 86°	below 90%
100 Penetration asphalt	50-75%

Fuel Oil

Petroleum as a fuel for use in steam plants has considerable variations, the only feature common to all oils coming under this class being that it is free from gasoline.

The gravity varies according to the character of the oil and the amount of light constituents that have been distilled out of it. The following table shows typical gravities of fuel oil from different sources:

	Gravity
Mexican fuel oil	12.6°Be′
Paraffin base fuel oil	27.5°Be′
California fuel oil	15.5°Be′
Towanda fuel oil	26.0°Be′
Mid Continent heavy fuel oil	23.5°Be′
Typical Mid Continent	26.5°Be′
Garber, Oklahoma, fuel oil	31.3°Be′

The chief property making fuel oil available for use is the ease with which it flows or its viscosity. The viscosity is not proportional to the gravity as is indicated by the following table:

VISCOSITY AND GRAVITY OF FUEL OILS.

Source.	Gravity	Viscosity at 70°F
California Crude	16.9	5400
Residuum from same after cracking	15.5	414
Heavy Kansas Crude	19.7	3360
Residuum from same after cracking	21.2	178
Heavy Mid Continent Fuel Oil	23.5	810
Residuum from same after cracking	21.2	135
Garber Fuel Oil	31.3	183
Residuum from same after cracking	28.0	70
Mexican Heavy Flux Oil	10.8	14500
Residuum from same after cracking	12.6	530
Average Mid Continent Fuel Oil	27.5	272
Residuum from same after cracking	23.7	88

Fuel oil has a remarkably constant heating value based on British thermal units per pound of oil. Oil free from water has a higher B. T. U. per pound and a lower B. T. U. per gallon, the lighter the oil and a lower B. T. U. per pound and a higher B. T. U. per gallon the heavier the oil. This is set forth in the curves on page ~~47.~~ 59 .

As compared with other sources of heat the theoretical amount of heat obtainable from petroleum or fuel oil as determined when the combustion is complete and the absorption of heat is complete is as follows:

1,000,000 B.T.U. of petroleum at $1.00 per bbl. costs $0.18.
1,000,000 B.T.U. of Cherokee slack coal @ $3.00 per ton=$0.13.
1,000,000 B.T.U. of natural gas @ $0.30 per 1000 cu. ft. = $0.30.
1,000,000 B.T.U. of coal gas at 0.50 per 1000 cu ft. = $0.79.
1,000,000 B.T.U. of electricity @ 1c per k.w. hr. = $2.93.

As to the actual heating value of fuel oils from various sources the following is representative:

HEATING VALUE OF FUEL OILS.

	Mid-Continent fuel oil Avg. 1255 samples	Light Mid Continent	Heavy Mid Continent	Towanda Fuel Oil	Gas Oil	Mexican
Specific gravity	0.892	0.863	0.922	0.921	0.856	0.975
Baume' gravity	26.9	32.2	21.8	22.0	33.5	12.6
Weight per gallon (lbs.)	7.43	7.18	7.68	7.67	7.13	8.25
Heat value B.T.U. per lb	19376	19580	19170	19175	19635	18710
Heat value B.T.U. per gal	143950	140580	147220	147600	139990	154360
Flash point	125°F	110°F	132°F	180°F	170°F	250°F
Sediment	1.0%	0.2%	1.5%	1.0%	0.0%	2.0%
Sulphur	0.30	0.24	0.65	0.75	0.05%	2.5%

It is to be noted that purchasers obtain more heat from a heavy fuel oil, as it is purchased on the basis of the gallon.

The chief impurities found in fuel oil are water or brine and asphaltic sediment. The asphaltic sediment has almost as great heating value as the oil itself but the brine or water very greatly diminishes the heating value as well as interfering with the mechanical use of the oil.

The price of coal is the most important factor governing the price of fuel oil. In a general way it may be said that one unit of heat from oil will produce the same amount of steam as 1.4 units of heat from coal. This takes into consideration the higher efficiency in using the oil, the greater ease in handling, the absence of certain mechanical features attendant upon the use of coal but does not consider the greater flexibility of the oil where this is a necessary feature of the power plant. One pound of oil is equivalent to 2½ pounds of coal, or one barrel of oil is equivalent to .45 ton of coal. Oil at $2.00 per barrel is equivalent to slack coal at $4.45 per ton. This assumes that the slack has a heating value of about 10,000 to 11,000 B.T.U. per pound.

SPECIFICATIONS FOR FUEL OIL OF U. S. NAVY.

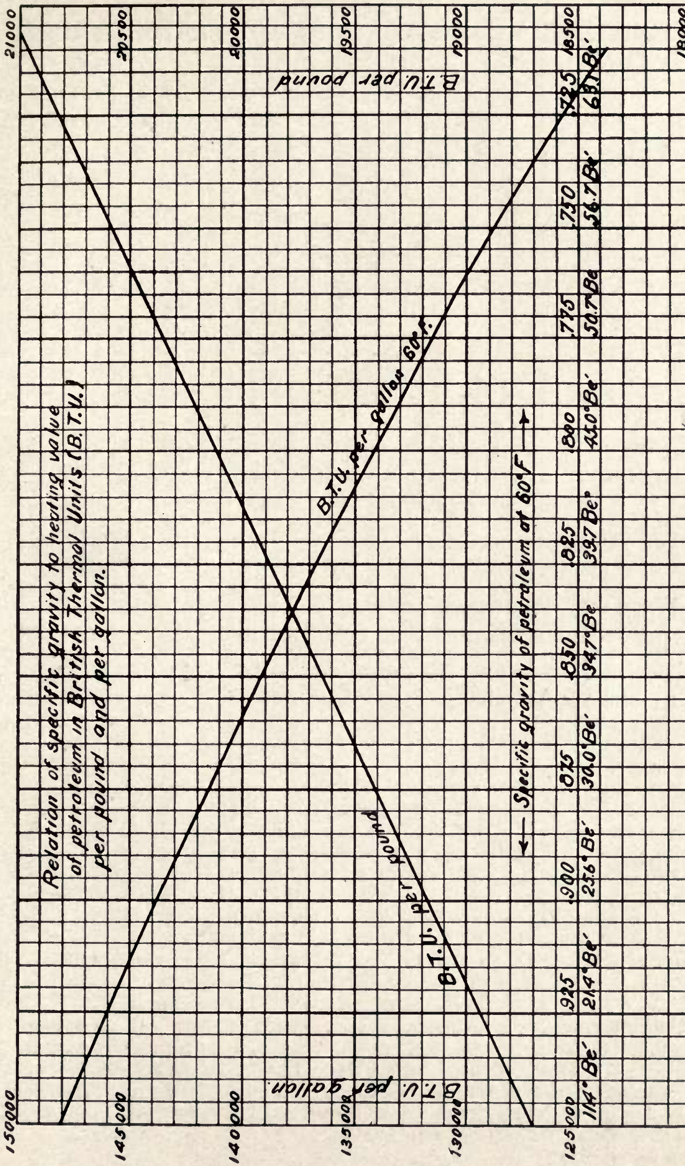
(a) Fuel oil shall be a hydrocarbon oil of best quality, free from grit, acid and fibrous and other foreign matter likely to clog or injure the burners or valves.

(b) The unit of quantity to be the barrel of 42 gallons of 231 cubic inches at a standard temperature of 60°F. For every variation of temperature of 10°F from the standard 0.4 of 1 per cent shall be added or deducted from the measured or gauged quantity for correction.

(c) Flash point shall never be under 150°F as a minimum (Abel or Pensky Martin's closed cup) or 175°F (Tagliabue open cup) and not lower than the temperature at which the oil has a viscosity of 8 Engler (water=1 Engler). Example: If an oil has a viscosity of 8 Engler when heated to 186°F, then 186°F is the minimum flash point at which this oil will be accepted.

(d) Viscosity at 100°F not greater than 200 Engler.

(e) Water and sediment not over 1 per cent. If in excess of 1 per cent the excess to be subtracted from the volume; or the oil may be rejected. Note: If an Engler viscosimeter is not available, the Saybolt standard universal viscosimeter may be used, and 280 seconds Saybolt will be considered equivalent to 8 Engler and 7000 seconds Saybolt will be considered equivalent to 200 Engler. Water at 60°F=30 seconds Saybolt.


Relation of specific gravity to heating value of petroleum in British Thermal Units (B.T.U.) per pound and per gallon.
B.T.U. per pound
B.T.U. per gallon
B.T.U. per gallon 60°F.
B.T.U. per pound
← Specific gravity of petroleum at 60°F →
21000
20500
20000
19500
19000
18500
18000
150000
145000
140000
135000
130000
125000
.725 63.1 Be'
.750 56.7 Be'
.775 50.7 Be'
.800 45.0 Be'
.825 39.7 Be'
.850 34.7 Be'
.875 30.0 Be'
.900 25.6 Be'
.925 21.4 Be'
11.4 Be'

Heating Value of Various Substances

	Calories per gram.	B.T.U. per lb. of combustible matter.
Alcohol, grain	7,054	12,697
Alcohol, wood	5,330	9,594
Asphalt, 60° pen.	9,532	17,159
Benzol	10,030	18,054
Carbon or Coke	8,137	14,647
Gas, Acetylene	11,527	20,749
Gas, Coal	4,440	7,990
	7,370	12,266
Gas, Methane	13,344	24,019
Gas, Water	2,350	4,230
Gas, Hydrogen	34,462	62,032
Iron	1,582	2,848
Coal, Pa. Anthracite	8,266	14,880
Coal, West Va. Bituminous	8,778	15,800
Coal, Wyoming Lignite	7,444	13,400
Coal, North Dakota Lignite	6,411	11,540
Coal, Kansas Bituminous	8,461	15,230
Coal, Illinois Bituminous	8,056	14,500
Coal, Cannel (Missouri)	8,980	16,165
Coal, Peat	5,940	10,692
Cottonseed Oil	9,500	17,100
Gasoline, avg.	11,528	20,750
Fuel Oil, avg.	10.833	19,500
Shale Oil	10,970	19,750
Paraffin wax	11,140	20,050
Sulphur	2,241	4,034
Wood	4,750	8,550
Naphthalene	9,690	17,442
Gilsonite	9,944	17,900
Hard Asphalt from petroleum	9,989	17,980
Blown Asphalt from petroleum	10,210	18,380

The following table is useful in the calculation of capacities of reservoirs and tanks and in quickly converting different measures of petroleum and water into each other.

Measurement of Water and Petroleum at 60° F.

Mutiply these values by the specific gravity of the petroleum. Specific Gravity of average crude oil =0.850; fuel oil=0.900; gasoline=0.750; kerosene=0.820; gas oil=0.850.

	Cubic foot	Cubic inch	U. S. Gallon	Imperial Gallon	Liter	Petroleum Barrel	Pound	Kilo-gram	Metric Ton
Cubic foot......	1.000	1728.	7.48	6.23	28.317	0.1781	62.37	28.29	.02829
Cubic inch.......	.0005787	1.000	.004329	.003605	.016387	$1.306.10^{-4}$	.03609	.01637	$1.637.10^{-5}$
U. S. Gallon.....	.13367	231.	1.000	.8328	3.785	.02381	8.338	3.782	.003782
Imperial Gallon..	.1605	277.4	1.201	1.000	4.545	.02859	10.01	4.541	.004541
Liter	.03532	61.03	.2642	.2200	1.000	.00629	2.203	.999034	.000999
Petroleum Barrel	5.615	9703.	42.00	34.98	159.3	1.000	350.2	158.85	.15885
Pound (Av.)....	.01603	277.1	.1199	.0999	.4539	.002856	1.000	.45359	.0004536
Kilogram	.03535	61.08	.2644	.2202	1.001	.006296	2.205	1.000	.001
Metric ton.......	35.35	61080.	264.4	220.2	1001.	6.296	2205.	1000.	1.000
Pood (Russian).	.5791	1000.	4.331	3.607	16.40	0.1031	36.12	16.38	.01638

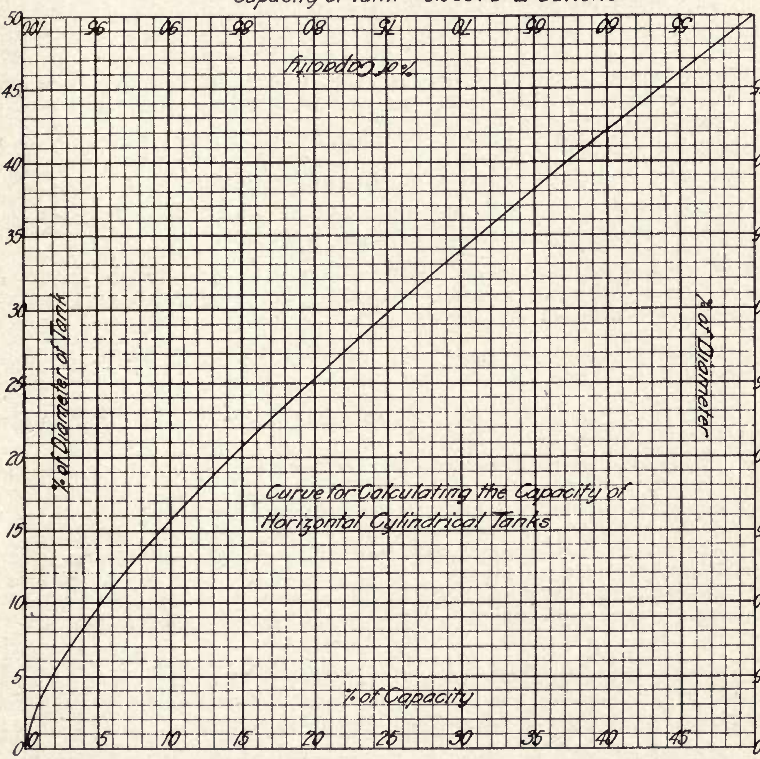
Horizontal Cylindrical Tank Capacity Table

Diameter		Capacity	Capacity		Diameter
1%	=	.17%	1%	=	3.3%
2%	=	.48%	2%	=	5.2%
3%	=	.87%	3%	=	7.0%
4%	=	1.34%	4%	=	8.2%
5%	=	1.87%	5%	=	9.7%
6%	=	2.45%	6%	=	11.0%
7%	=	3.08%	7%	=	12.2%
8%	=	3.75%	8%	=	13.4%
9%	=	4.46%	9%	=	14.5%
10%	=	5.20%	10%	=	15.6%
11%	=	5.98%	11%	=	16.7%
12%	=	6.79%	12%	=	17.8%
13%	=	7.64%	13%	=	18.8%
14%	=	8.51%	14%	=	19.8%
15%	=	9.41%	15%	=	20.8%
16%	=	10.33%	16%	=	21.7%
17%	=	11.27%	17%	=	22.6%
18%	=	12.24%	18%	=	23.6%
19%	=	13.23%	19%	=	24.5%
20%	=	14.24%	20%	=	25.4%
21%	=	15.27%	21%	=	26.3%
22%	=	16.31%	22%	=	27.2%
23%	=	17.37%	23%	=	28.1%
24%	=	18.45%	24%	=	29.0%
25%	=	19.55%	25%	=	29.8%
26%	=	20.66%	26%	=	30.6%
27%	=	21.78%	27%	=	31.5%
28%	=	22.92%	28%	=	32.4%
29%	=	24.07%	29%	=	33.2%
30%	=	25.23%	30%	=	34.0%
31%	=	26.40%	31%	=	34.8%
32%	=	27.58%	32%	=	35.7%
33%	=	28.78%	33%	=	36.5%
34%	=	29.98%	34%	=	37.3%
35%	=	31.19%	35%	=	38.1%
36%	=	32.41%	36%	=	38.9%
37%	=	33.63%	37%	=	39.7%
38%	=	34.87%	38%	=	40.5%
39%	=	36.11%	39%	=	41.3%
40%	=	37.35%	40%	=	42.1%
41%	=	38.60%	41%	=	42.9%
42%	=	39.86%	42%	=	43.7%
43%	=	41.12%	43%	=	44.5%
44%	=	42.38%	44%	=	45.3%
45%	=	43.64%	45%	=	46.1%
46%	=	44.91%	46%	=	46.9%
47%	=	46.18%	47%	=	47.7%
48%	=	47.45%	48%	=	48.5%
49%	=	48.73%	49%	=	49.2%
50%	=	50.00%	50%	=	50.0%

CURVE FOR CALCULATING THE CONTENTS OF HORIZONTAL CYLINDRICAL TANKS BASED ON THE FOLLOWING FORMULA

$$\text{CONTENTS} = \frac{L}{231}\left(0.004363\ D^2 \operatorname{Cos}^{-1}\frac{D-2X}{2}\sqrt{X(D-X)}\right)$$

D = DIAMETER OF TANK IN INCHES
L = LENGTH (inches)
X = DEPTH OF FLUID IN TANK (inches)
Capacity of Tank = $0.0034\ D^2L$ Gallons



Miscellaneous Facts Concerning Heating by Oil

Good practice in the atomization of fuel oil requires an average of .3 pound of steam per pound of oil burned.

One pound of fuel oil requires 15-16 pounds or 200-215 cubic feet of air for complete combustion.

The stack gases from an oil furnace for the highest efficiency should not contain less than 15% of carbon dioxide.

The usual temperature of an oil flame with complete combustion and without an excess of air is about 3750°F. (Natural gas flame= 3250°F.)

One pound of oil will yield on combustion, 16-7 pounds of gases of combustion or 400-500 cubic feet at a temperature of 400°F.

Oil is successfully used in melting iron and steel scrap. For this purpose it is much superior to coal on account of the absence of mineral matter and the very much smaller amount of sulphur.

One barrel of oil will melt one ton of steel in the reverberatory furnace, with the furnace walls already hot.

A typical malleable iron foundry by the changing of the furnaces from coal to oil fuel increased the strength of their castings, 100% and increased the output, 20%.

Diesel engines consume from .45 to .7 pound of heavy oil per brake H.P. per hour.

The advantages of oil fuel installations for locomotives and boats have been found to be as follows:

(a) Economy of space reserved for carrying fuel.
(b) Ease in filling tanks.
(c) Rapidity of time in meeting a varying load on boiler.
(d) Ability to force boiler to extreme duty in case of emergency.
(e) Absence of smoke under light, normal working conditions.
(f) Short height of stack.
(g) Superior personnel available for the operation of the burners.
(h) Ability to secure and maintain higher speed with oil fuel than with coal.

In the distillation of crude oil in which 50% of the crude is distilled off as benzene and kerosene, in good practice, 2.8 barrels of fuel oil are used per 100 barrels of crude oil treated.

For all refining purposes in the production of gasoline, naphtha and kerosene only, from 6 to 7 barrels of fuel oil are required for each 100 barrels of crude treated, assuming that 50% of the lighter hydro carbons are distilled from the crude.

The specific heat of petroleum is about 0.5 (.49-.53), the heat of vaporization averages about 130 British Thermal Units per pound, and the heat of fusion 63. B.T.U. per pound (Paraffin).

Economy of Lubrication

The economical transmission of power is largely dependent upon the maximum reduction of friction.

The purpose of lubrication is to overcome friction in so far as possible and to prevent wear and deterioration of adjacent moving parts.

It is claimed that from 40% to 80% of all power produced by machinery is lost in friction and a very considerable part of this is lost in avoidable friction due to improper lubrication.

THEORY OF LUBRICATION.

A lubricant should prevent direct contact between the bearings and the moving parts of machinery, thus substituting for metallic friction and wear the much smaller internal friction of the lubricant. The more completely this result is attained under the conditions of temperature, speed and pressure, the more valuable the lubricant from a mechanical point of view. Whether the mechanically most efficient lubricant is the most economical depends somewhat on the ratio of efficiency, the amount used and the price of the material. Greases have a low mechanical efficiency compared with liquid oils, but from the point of economy and cleanliness they are far superior.

Only liquids with great tendency to adhere are suited for lubrication, since only these have the property to penetrate by capillarity where journal and bearings are the closest and where the danger of contact and wear is the greatest. The lubricating oils prevent direct contact of the metal surfaces because of their adhesion to these surfaces and because their viscosity keeps them from being squeezed out by the pressure on the bearing.

Experience has shown that the power to adhere to metals increases with the viscosity of the oil. Since the danger that an oil will be pressed out increases with the pressure on the bearings, it is advisable for high pressures to use oils of considerable viscosity.

With low pressure and high speed there should be used a very mobile oil, with higher pressure and great velocity, more viscous oils. If, for example, a spindle rotating with practically no pressure, but very rapidly, were lubricated with a very viscous oil, it would mean a lavish waste of power. But to lubricate a transmission gear with a mobile oil would be a waste of lubricant, while the use of a heavy grease would be entirely suitable. In fact, the use of a solid lubricant, graphite, with heavy oils as a vehicle, has proven most desirable in the case of very heavy bearings and transmission gears with enormous pressures.

The oil should not lose its power of reducing friction by evaporation, gumming or by acting chemically on the metal of the bearing or journal.

The oil or grease should not solidify or greatly change its viscosity under conditions of use.

CHARACTER OF LUBRICATING OIL.

The principal source of lubricating oil is petroleum, from which the lighter components (naphtha and kerosene) have been removed by distillation, the residue thus obtained being used directly as a lubricant or separated by distillation into various fractions. By removing some of the fractions as well as by mixing others, a variety of prod-

ucts may be obtained with special properties (viscosity, flash point, cold test and specific gravity).

This is the principle on which the industry is based. The separate fractions are further refined to remove odor, resinous materials, etc., as well as to attain the desired lightness of color. This is accomplished by means of sulphuric acid, agitating with a stream of air, the acid being later removed by washing with alkali or water; the purification may also be brought about by filtration through fuller's earth (customary in the United States).

In Europe the oil is distilled with superheated steam, recently also with partial vacuum, direct firing being avoided to prevent decomposition. The temperature of the superheated steam is kept somewhat higher than that of the still. Commercially the distillates are cooled and separated according to specific gravity, flash point and viscosity.

In the United States, direct firing is much used in separating the crude oil fractions, thus increasing the yield of illuminating oils. The refining, however, is carried on with superheated steam.

PHYSICAL TESTS FOR LUBRICANTS.

1. **Flash and burning points** of lubricants are the respective temperatures at which the vapors arise in sufficient amount to ignite and to burn continuously. They should be high enough to prevent any danger of fire in using the oil and to be assured that a light oil has not been added to a heavy oil to regulate viscosity. With the same viscosity asphaltic base oils (Texas, California and Mexico) have a lower flash point and a higher specific gravity than paraffin base oils (Pennsylvania and West Virginia).
2. **Specific Gravity** is the relation of the weight of a given volume of oil to the weight of the same volume of water. The oil trade usually uses the Baume' scale for gravity, which is entirely arbitrary (see tables). The paraffin oils with the same viscosity are lighter (have a higher gravity—Baume') than the asphaltic or semi-asphaltic oil. Gravity is not a measure of the quality of a lubricating oil.
3. **Viscosity** is the most important property for lubrication. The viscosity is expressed in the terms of the Saybolt Universal Viscosimeter in this country, the Engler in Germany and the Redwood in England (See conversion factors on page 70).
   Paraffin oils lose their viscosity most readily in use in an explosion cylinder by reason of the greater ease in decomposing to lighter products than do asphaltic oils (see also cracked lubricating oils).
4. **Carbon.** The fixed carbon is a most harmful property in lubricants for explosion motors, such as automobiles. High fixed carbon is found in poorly refined and blended oils. It is higher in asphaltic than in Pennsylvania or Mid-Continent oils with the same refining. Less carbon is present in light oils.
5. **Cold test** determines the lowest temperature at which the oil will pour. A low cold test is desirable for ease in circulating and handling in cold weather. A low cold test for motor oils indicates the absence of heavy ends that produce excessive carbon in the cylinder.
6. **Color** is not an index of the value of a lubricating oil. The lighter the color, other things being equal, the purer is the oil.

7. **Free acid** should be, and usually is, absent. It is an indication of mineral acid that has not been neutralized and washed out in refining or of the presence of naphthenic acids.

The qualities of various lubricating oils are as follows:

Viscosity at	Spindle	Light Machinery	Heavy Machinery	Automobile	Engine	Steam Cylinder	Large Gas Cylinder
70°F	75-500	375-750	750-1875	470-1100	300-400	....	2800-4000
100°F	......	180-220	....	160- 400	130-150	....	....
122°F	75- 90	....	110- 280	....	....	1100	300- 560
210°F	......	40- 50	45- 60	40- 55	44- 47	120- 150	....
Flash point °F Min.	140	160	390	350	430	525	450
Cold test °F	10	5	10 40	10	25	45	40
°F	10	5	10- 40	10	25	45	40
Gravity Be'				19- 32	23- 25	24- 30	

EFFECT OF CRACKING ON THE LUBRICATING QUALITIES OF OIL.

In the cracking of petroleum by heat the paraffin hydrocarbons are most readily decomposed into lighter hydrocarbons. The lubricating hydrocarbons remaining in cracked oil are therefore not paraffin but consist chiefly of naphthenes and aromatics. In other words, cracking reduces the viscosity of heavy hydrocarbon oils based on the same gravity. This fact is set forth in the patent to Burton (U. S. No. 1,167,884 Jan. 11, 1916) as follows:

Lubricating fractions made from Mid Continent Crude Petroleum

Baume' Gravity	Viscosity at 100° (Saybolt Viscosimeter)
25.0	235
26.0	190
26.0	165
26.5	145
27.5	100

Lubricating fractions made from California Crude Petroleum

Baume' Gravity	Viscosity at 100°
18.8	449
20.4	235
20.6	339
21.6	146
21.8	167
22.5	139

Lubricating fractions made from Cracked Petroleum Residua

Baume' Gravity	Viscosity	Gravity	Viscosity
28.9	36	15.2	88
26.5	38	15.0	89
23.8	42	14.7	97
21.5	45	14.1	105
21.1	51	13.2	110
20.2	52	13.0	116
18.7	58	12.0	158
17.8	62	10.8	198
17.2	65		
16.7	66		
15.8	76		

Natural Hydrocarbons—Vacuum Distilled

Table showing the properties of vacuum distilled hydrocarbons and atmospheric pressure forced fire distilled hydrocarbons of a heavy residuum from Mid Continent oil.

Fraction	Gravity	Viscosity	Sulphur
0—10%	0.868 31.3°Be′	46	0.39%
10—20%	0.877 29.6°Be′	60	0.35%
20—30%	0.895 26.4°Be′	143	0.43%
30—40%	0.909 24.0°Be′	293	0.53%
40—50%	0.920 22.1°Be′	740	0.76%
50—60%	0.920 22.1°Be′	745	0.68%
60—70%	0.920 22.1°Be′	1058	0.70%
70—80%	0.920 22.1°Be′	2600	0.56%

HYDROCARBONS FROM FORCED FIRE DISTILLATION OF SAME OIL.

Fraction	Gravity	Viscosity
0—10%	0.864 32.1°Be′	51
10—20%	0.877 29.6°Be′	69
20—30%	0.888 27.6°Be′	109
30—40%	0.893 26.7°Be′	141
40—50%	0.894 26.6°Be′	141
50—60%	0.887 27.8°Be′	106
60—70%	0.878 29.4°Be′	75
70—80%	0.877 29.6°Be′	69

EFFECT OF TEMPERATURE ON VISCOSITY OF NATURAL MID CONTINENT HEAVY OILS.

		Av'ge Mid-Continent Fuel Oil 26.8°Be′	Heavy Kansas Crude 19.6°Be′
60°F	=	294.	....
70°F	=	190.	3360.
100°F	=	94.	1250.
120°F	=	70.	680.
150°F	=	55.	328.
212°F	=	41.	105.

(Viscosity is expressed in terms of the Saybolt Universal)

Factors to Reduce Engler Numbers to Saybolt or to Redwood Times

Engler Number	Factor to Reduce Engler Number to Saybolt Time	Factor to Reduce Engler Number to Redwood Time
1.00	28.1	26.7
1.05	28.4	27.0
1.10	28.8	27.2
1.15	29.1	27.4
1.20	29.5	27.6
1.25	29.8	27.8
1.30	30.1	28.0
1.35	30.4	28.2
1.40	30.8	28.3
1.45	31.1	28.5
1.50	31.5	28.6
1.60	32.0	28.8
1.70	32.5	29.0
1.80	33.0	29.2
1.90	33.5	29.4
2.00	33.9	29.6
2.10	34.2	29.7
2.20	34.5	29.9
2.30	34.8	30.0
2.40	35.1	30.1
2.50	35.3	30.2
2.60	35.5	30.3
2.70	35.7	30.3
2.80	35.9	30.4
2.90	36.1	30.4
3.00	36.2	30.5
3.50	36.7	30.7
4.00	37.0	30.9
4.50	37.3	31.1
5.00	37.4	31.2
6.00	37.5	31.3
...	....	....
50.00	37.5	31.3

Factors to Reduce Saybolt Times to Engler Numbers or to Redwood Times

Saybolt Time, Seconds	Factor to Reduce Saybolt Time to Engler Number	Factor to Reduce Saybolt Time to Redwood Time
28	0.0357	0.95
30	0.0352	0.95
32	0.0346	0.94
34	0.0342	0.94
36	0.0337	0.94
38	0.0334	0.93
40	0.0330	0.93
42	0.0327	0.92
44	0.0323	0.92
46	0.0320	0.91
48	0.0317	0.91
50	0.0314	0.90
55	0.0308	0.90
60	0.0302	0.89
65	0.0297	0.88
70	0.0293	0.87
75	0.0289	0.86
80	0.0286	0.86
85	0.0284	0.86
90	0.0282	0.85
95	0.0280	0.85
100	0.0279	0.85
110	0.0276	0.85
120	0.0274	0.84
130	0.0272	0.84
140	0.0271	0.84
160	0.0269	0.84
180	0.0268	0.84
200	0.0267	0.84
...	......	....
1800	0.0267	0.84

Factors to Reduce Redwood Times to Saybolt Times or to Engler Numbers

Redwood Time	Factors to Reduce Redwood Time to Saybolt Time	Factors to Reduce Redwood Time to Engler Number
26	1.05	0.0377
28	1.05	0.0372
30	1.06	0.0368
32	1.06	0.0364
34	1.07	0.0361
36	1.07	0.0358
38	1.08	0.0355
40	1.09	0.0353
42	1.10	0.0351
44	1.10	0.0349
46	1.11	0.0347
48	1.12	0.0345
50	1.13	0.0344
55	1.14	0.0340
60	1.15	0.0337
65	1.16	0.0335
70	1.16	0.0333
75	1.17	0.0331
80	1.18	0.0330
85	1.18	0.0329
90	1.18	0.0328
95	1.19	0.0327
100	1.19	0.0326
110	1.19	0.0325
120	1.20	0.0324
130	1.20	0.0322
140	1.20	0.0321
160	1.20	0.0321
180	1.20	0.0320
...	....	......
1500	1.20	0.0320

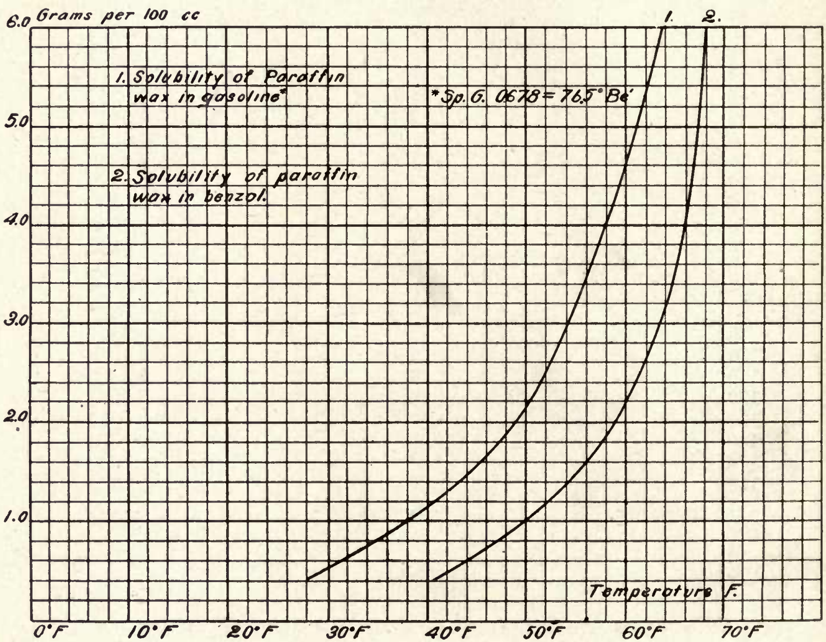
FACTORS FOR APPROXIMATE CONVERSION OF READINGS IN TERMS OF SAYBOLT UNIVERSAL TO OTHER INSTRUMENTS.

	70° F	100° F	212° F	338° F
To Saybolt "A"	.50	1.00	...	...
To Saybolt "C"	...	...	.46	.72
To Engler	.035	.030	.028	.027
To Tagliabue	.25	.28	.51	...
To Penn. R. R. Pipet	.30	.47	.51	.94
To Scott	.13	.13	...	...
To Redwood	.83	.85	.88	.90
To Magruder Plunger	1.25	1.04	2.00	...
To Ostwald	1.90	1.85	1.68	1.30

Paraffin Wax

Paraffin wax is valued by the color, melting point and the specific gravity. The price of the crude wax having a melting point of from 103° F to 108° F is about 6c per pound, while the highly refined wax having a melting point of up to 140° F is worth about 17c per pound.

Paraffin wax is ordinarily obtained from petroleum; also from shale oil and ozocerite. Paraffin exists in crude petroleum in the form of protoparaffin, in which condition it does not crystallize out and cannot be expressed from oil at low temperatures. In order to



obtain it in condition for refrigeration and filtration, the heavy oil is subjected to a destructive distillation, thereby producing the crystalline pyroparaffin.

Pennsylvania petroleum furnishes from 1½% to 2% paraffin wax, some petroleum such as one in Roumania giving as much as 10%.

The wax distillate from which paraffin is obtained contains ordinarily about 10% of wax. This distillate has a gravity of from 33° Be' to 35° Be' and distills over at a temperature of 500° F to 700° F. The paraffin is freed from oil by the sweating process after filtration.

Color and Odor in Refined Petroleum

Most distillates from petroleum contain sufficient foreign matter to give an undesirable odor or a yellowish to red color.

The odor in natural distillates is due ordinarily to sulphur compounds, characteristic of which is hydrogen sulphide. Gasoline or light hydrocarbons produced by cracking have a more or less offensive odor even though sulphur is absent in any appreciable quantity. In a general way, color is present in proportion as the odor is more disagreeable. The color of petroleum products is thought to be largely due to nitrogen compounds. Light hydrocarbons produced by cracking have a higher color the larger the amount of nitrogen in the heavy oils cracked, as a general rule. Cracked products from paraffin hydrocarbons such as those from Oklahoma give a yellowish color in the distillate above 300° F, though they may be colorless below 300° F. California cracked gasoline gives a red color, which is not noticeable immediately upon distilling, but becomes more intense as the gasoline is exposed to the action of the air. This coloring matter on standing largely settles out so that the redistilled gasoline may be free from color.

Kerosene, the first refined product of petroleum marketed on a large scale, was a yellow or dark red liquid. It was first produced from coal, and it was found in 1857 that (coal oil) could be deodorized and decolorized by treatment with sulphuric acid, and this is the process that is in general use at the present time. 66° Be′ sulphuric acid is ordinarily used, as it reacts upon the unsaturated compounds and the sulphur compounds and the nitrogenous compounds in the oil by forming substances which dissolve largely in the sulphuric acid. The shrinkage of the oil treated may vary from almost nothing up to 10%, depending upon the character of the oil being refined. In ordinary natural distillates, one pound of acid per barrel is commonly sufficient, but with cracked oil as much as 3% of acid is often required. Even then the treatment is often not sufficiently severe and oleum or Nordhausen sulphuric acid, which contains an excess of sulphur trioxide, is necessary. This is the case with California and Towanda oil. After treatment with sulphuric acid, thorough washing and neutralization with soda is always necessary.

Other chemicals may be quite successfully used in removing the odor of cracked gasoline, among these being sodium plumbite, copper oxide, manganese dioxide, potassium permanganate, sodium chromate, aluminum chloride and chlorine.

The "bloom" or fluorescence of mineral oils is supposed to be due to the presence of asphalt-like or pitchy material in colloidal condition. This is overcome by the use of mono-nitro-napthalene ($C_{10}H_7NO_2$) in small amounts. The physical means of removing color and to some degree odor is by the use of filtration through fuller's earth. This is common practice with lubricating oils.

Other methods of removing color are not completely successful.

THE EFFECT OF SULPHUR IN THE REFINING OF PETROLEUM.

Sulphur is present in all petroleums. (See page 18.) It exists in the elementary form dissolved in the oil or in a chemically combined form as the sulphides of hydrocarbon groups. When it is found in very large amount there is usually a considerable amount of free or

elementary sulphur. The alkyl or organic sulphides give to petroleum its characteristic odor. High sulphur petroleum residues such as Trinidad asphalt have characteristic odors of complex sulphur compounds. Lighter gasoline-bearing oils such as the Ohio and the Butler County, Kansas, oils have characteristic odors varying from that of pure hydrogen sulphide to that of the complex organic sulphides such as exist in natural asphalt. A typical distillation of a heavy crude oil by means of steam shows the following results as to distribution of sulphur:

Fraction	Specific Gravity	Sulphur
0-10%	0.868 = 31.3° Be′	0.39%
10-20%	0.877 = 29.6° Be′	0.35%
20-30%	0.895 = 26.4° Be′	0.43%
30-40%	0.909 = 24.0° Be′	0.53%
40-50%	0.920 = 22.1° Be′	0.70%
50-60%	0.920 = 22.1° Be′	0.70%
60-70%	0.917 = 22.7° Be′	0.70%
70-80%	0.917 = 22.7° Be′	0.56%

This condition does not hold in the case of all oils, particularly the oils from Butler County, Kansas, which are characterized by the giving off of the rather large amount of hydrogen sulphide in the early part of the distillation.

Sulphur causes trouble in the refinery in the purification of the distilled products and in the corrosive effect of the oxidized sulphur.

At the time that the first sulphur oils were discovered in Ohio (.8% sulphur) they brought a price of only 14c per barrel, while at the same time the Pennsylvania oils (0.04% sulphur) sold at $2.25 per barrel. According to Frash, it is a comparatively simple matter to free petroleum of elementary sulphur or hydrogen sulphide, but the sulphur compounds, which are the cause of the offensive odor, are very stable and cannot easily be broken up into hydrogen sulphide or other sulphur compounds which can be eliminated. It was because of the presence of these stable compounds that high sulphur oils for many years resisted all efforts to refine it.

These complex sulphur compounds have the peculiarity of dissolving a number of metallic oxides. When the oil is saturated with all of the oxide which can be carried, the disagreeable odor disappears. It tends to reappear, however, when an attempt is made to separate the metal from the oil unless more oxide is used than is necessary to precipitate all of the sulphur, in which case complete desulphurization of the petroleum is effected. The Frash method, which has been successfully used for nearly thirty years by the Standard Oil Co., consists in the use of 1,000 pounds of the copper oxide to 2,000 barrels of distillate. The copper is recovered by filtering and roasting.

In distillation the chemical action of the sulphur may result from the direct combination of the sulphur with the iron or by the oxidation of the sulphur with formation of sulphonic acids, which pit the iron, particularly of the condensers.

Refining of Oil for Road Building and Paving Purposes

The various methods of refining which yield residues adaptable or used for road building and paving purposes are as follows:

Sedimentation.
Dehydration.
Fractional distillation by direct fire.
Forced fire distillation with direct fire.
Steam distillation.
Inert gas distillation.
Air blowing.

In the types of oil which are ordinarily used for making asphalt or road binders, water is one of the most common impurities. The water is ordinarily salt water and may contain more or less other mineral matter than the salt. These impurities are insoluble in the bitumen proper, and, as they differ from the bitumen in specific gravity, they may be removed wholly or in part by the process of sedimentation or separation by gravity. In the more fluid petroleums sedimentation occurs during storage in the large tanks and the water is ordinarily automatically drawn off from the bottom of the tank by reason of the different pressure produced by the salt water and by the oil. However, a small amount of emulsified water nearly always remains in all petroleums, so that there will always be a small amount of sediment. If the petroleum is very heavy and viscous, approximately equal in gravity to water, then the water will remain emulsified and will not separate by gravity. This type of oil happens to be the most suitable in quality for producing asphalt, and special means of removing this water is necessary before the oil can be reduced to the desired consistency. The dehydration processes are designed primarily for removal of the water in the bituminous material which will not completely separate by sedimentation. It is desirable to do this before distillation because of the fact that the presence of the water will cause foaming when the mixture is heated to the temperature of boiling water. Dehydrating plants vary considerably in design, but those more commonly used for petroleum in California are spoken of as topping plants. In this sort of plant the oil is pumped with or without pressure through a length of pipe containing many bends and turns, so that the oil is considerably stirred. The pipe coils are set in furnaces, so that they may be suitably heated to a temperature above that of boiling water. This pipe discharges the foam into a large expansion chamber, where the water and more volatile constituents separate in the form of vapor, which is condensed in an ordinary condenser for the recovery of the light products. This sort of plant is commonly spoken of as a pipe still. From the pipe still the oil passes through another line, direct to a large batch still, where it is subjected to the ordinary fractional distillation.

The essential principle in the distillation of an oil for road purposes is that it shall distill at a temperature sufficiently low to prevent the decomposition of the hydrocarbons. Since asphalt hydro-

carbons begin to decompose at a temperature of 600° F or slightly below, it is desirable that the fire distillation be carried only to that temperature. After this temperature has been reached, the usual method is to blow superheated steam, which mechanically carries over the more volatile hydrocarbons at a temperature much below the actual boiling point.

This distillation has a special action in removing the paraffin compounds which are particularly undesirable in that they have very little ductility and cementition value. The distillate will contain any light oils such as are used as spindle oils and for general lubrication, as well as any paraffin wax. It is particularly desirable in this distillation to prevent the formation of free carbon or coke. The distillation with steam may be carried down until the residue shows a penetration of about 10 millimeters.

A method of distillation which gives very great yields of solid or semisolid asphalt even from semiparaffin base oils is that of blowing the oil at moderately high temperature with air. This in many Mid Continent oils gives much more asphalt than naturally exists in the oil. The action of the air is to produce a more viscous product which is very much less susceptible to temperature changes than the natural asphalt. It is strictly a chemical transformation process formed from the hydrocarbons in the oil which are ordinarily not useful for asphalt making purposes. It has been found from practical experience that this type of asphalt is not sufficiently cementitious and ductile to be used for ordinary paving purposes in producing first-class asphalt pavement. It can, however, be successfully used and is in great demand for waterproofing purposes, for filler in brick and wood block pavement and for roofing purposes and for fluxing ductile asphalt.

The best types of petroleum for asphalt paving purposes are those from California, Mexico, Trinidad and Texas.

ASPHALT PAVEMENT.

Asphalt is a black non-oxidized bituminous hydrocarbon, semi-fluid to hard in consistency, the heavy residuum from petroleum or occurring naturally. The residua from petroleum are known as oil asphalts and come most largely from California, Mexican, Texas and Mid Continent petroleums. The most commonly used natural asphalts are Trinidad, Bermudez, Cuban and Gilsonite.

The term asphalt is commonly applied to bituminous pavements, being mixtures usually of oil asphalt with dust, sand, gravel or rock in varying proportions from 6% to 20%. The terms "bitumen" or "asphaltic cement" are commonly applied to the pure asphalt material.

The types of asphalt construction now commonly used are:

1. Asphaltic concrete. This mixture is very common in localities where Joplin chats are available. It is known also as "Topeka Specification Pavement" and "Bituminous Concrete," but it might be called bituminous gravel. The stone it carries is of ½″ and ¼″ size.

2. Sheet asphalt is the original type of asphalt pavement laid in two courses, the bottom one with coarse stone, the top with sand mixed with the bitumen.

3. Bituminous concrete (Warren) is laid with coarse stone in the wearing surface.

4. Bituminous earth is laid without an appreciable amount of sand or rock.

There are two different basic principles involved in proportioning the mineral matter of an asphalt pavement. One is to so grade the coarse mineral particles that they support each other and interlock. The other is to produce a mastic of bitumen and finely divided earthy material that is rigid and self-supporting because of surface tension action. This mastic fills the voids in the coarse material and has a much higher melting point than the pure bitumen and does not so readily allow softening or movement of the pavement.

COMPOSITION OF NATURAL ASPHALT.

	Natural Trinidad	Ber-mudez	Gilsonite	Grahamite	Cuban
Bitumen	56.0%	94.0%	99.4%	94.1%	75.1%
Mineral Matter	36.8%	2.0%	0.5%	5.7%	21.4%
Specific Gravity	1.400	1.085	1.045	1.171	1.305
Fixed Carbon	11.0%	13.5%	13.0%	53.3%	25.0%
Melting Point, ° F	190	180	300	Cokes	240
Penetration	0.5	2.5	0	0	0
Free Carbon	6.0%	4.0%	0.1%	0.2%	3.5%
Sulphur (ash free basis)	6.5%	5.6%	1.3%	2.0%	8.3%
Petroleum ether soluble	65.0%	70.0%	30.0%	0.4%	41.1%
Total Carbon (ash free)	82.6%	82.5%		87.2%	
Hydrogen (ash free)	10.5%	10.3%		7.5%	
Nitrogen (ash free)	0.5%	0.7%		0.2%	

COMPOSITION OF OIL ASPHALTS.

	Mexican	Mid Continent Air Blown	California
Bitumen	99.5%	99.2%	99.5%
Mineral Matter	0.3%	0.7%	0.3%
Specific Gravity	1.040	0.990	1.045
Fixed carbon	17.5%	12.0%	15.0%
Melting Point °F	140	180	140
Penetration	55	40	60
Free Carbon	0.0	0.0	0.0
Sulphur (ash free basis)	4.50%	0.60%	1.65%
Petroleum Ether Soluble	70.0%	72.0%	67.0%
Cementing Properties	good	poor	good

Specifications for Asphaltic Cement for Asphalt Surface Mixture

Impurities

The asphaltic cement shall contain no water, decomposition products, granular particles or other impurities, and it shall not be homogeneous.

Ash passing the 200 mesh screen shall not be considered an impurity, but if greater than 1%, corrections in gross weights shall be made to allow for the proper percentage of bitumen.

Specific Gravity

The specific gravity of the asphaltic cement shall not be less than 1.000 at 77°F.

Fixed Carbon

The fixed carbon shall not be greater than 18%.

Solubility in Carbon Bisulphide

The asphaltic cement shall be soluble to the extent of at least 99% in chemically pure carbon bisulphide at air temperature and based upon ash free material.

Solubility in Carbon Tetrachloride

The asphaltic cement shall be soluble to the extent of at least 98.5% in chemically pure carbon tetrachloride at air temperature and based upon the ash free material.

Melting Point

The melting point shall be greater than 128°F and less than 160°F (General Electric method).

Flash Point

The flash point shall be not less than 400°F by a closed test.

Penetration

The asphaltic cement shall be of such consistency that at a temperature of 77°F a No. 2 needle weighted with 100 grams in five seconds shall not penetrate more than 9.0 nor less than 5.0 millimeters. For asphaltic cement containing ash, 0.2 millimeter may be added for each 1.0% of ash to give the true penetration.

Loss By Volatilization

The loss by volatilization shall not exceed 2% and the penetration after such loss shall be more than 50% of the original penetration. The ductility after heating as above shall have been reduced not more than 20%, the value of the ductility in each case being the number of centimeters of elongation at the temperature at which the asphaltic cement has a penetration of 5.0 millimeters. The volatilization test shall be carried out essentially as follows:

Fifty grams of the asphaltic cement in a cylindrical vessel 55 millimeters in diameter and 35 millimeters high shall be placed in an electrically heated oven at a temperature of 325°F and so main-

tained for a period of 5 hours. The oven shall have one vent in the top one centimeter in diameter and the bulb of the thermometer shall be placed adjacent the vessel containing the asphaltic cement.

Ductility

When pulled vertically or horizontally by a motor at a uniform rate of 5 centimeters per minute in a bath of water, a cylinder of asphaltic cement one centimeter in diameter at a temperature at which its penetration is 5 millimeters shall be elongated to the extent of not less than 10 centimeters before breaking.

EPITOME OF THE PURPOSES OF CERTAIN SPECIFICATIONS FOR ASPHALTIC CEMENT.

Impurities are a measure of the care with which the asphaltic cement has been refined and handled. Usually the presence of impurities in large quantities indicates a poor grade of asphalt. Water as an impurity would act as a diluent and would cause foaming in the kettle. Ash or mineral matter is not considered an impurity if it is a natural constituent of the asphaltic cement, but the mix and cementing value must be figured on the bitumen alone.

Specific Gravity of the asphaltic cement should be over 1.000. The advantage of a specific gravity more than 1.000 is that there will be less tendency for water to float out the asphaltic cement. The specific gravity is raised by the presence of mineral matter. Asphaltic oils of a penetration satisfactory for paving purposes always have a specific gravity greater than 1.000. Paraffin base oil and air-blown products usually have a specific gravity less than 1.000.

Fixed Carbon is a measure of the chemical consitution of an asphalt to some extent. Certain types of asphalt such as Mexican have naturally a constitution that yields a large amount of fixed carbon. Fixed carbon is largely used for determining the source and uniformity of an asphalt. Fixed carbon is not free carbon, but includes free carbon, which is practically absent in asphaltic cements.

Solubility in Carbon Bisulphide is a measure of the purity of an asphaltic cement. The cementing value, other things being equal, is proportional to the carbon bisulphide solubility. Any carbonaceous material such as coal tar or pitch is detected by the carbon bisulphide solubility test.

Solubility in Carbon Tetrachloride is very nearly the same as the solubility in carbon bisulphide. It is claimed that an asphalt having more than 1½% difference in the solubility in carbon bisulphide and carbon tetrachloride has been subjected to excessive heat in refining.

Melting Point is the temperature at which the asphaltic cement will flow readily. The melting point desired is dependent upon the mixture. If the amount of fine dust in the mineral aggregate is low, the asphalt should have a melting point higher than the highest temperature to which the pavement is subjected.

Flash Point is a measure of the amount of volatile hydrocarbons that are present in the asphalt and its readiness to decompose by heat.

Penetration is a measure of the consistency of the asphaltic cement. It is merely a quick convenient test for checking up numerous individual samples. The penetration is expressed in degrees and in accordance with the method of the American Society for Testing Materials, each degree representing 1-10th of a millimeter or 1-250th of an inch. The penetration, then, is the number of degrees that a No. 2 sewing needle when weighted with 100 grams will pass vertically into the A.C. at a temperature of 77°F(25°C) in 5 seconds The penetration to be desired will depend upon the climate, the nature of the traffic, the grading of the mineral particles, the amount of voids, the amount of compression attainable, the ductility and cementing strength of the A.C., and the amount of dust filler.

Loss By Volatilization is a measure of the amount of light hydrocarbons that are present in asphalt and is also a measure of the tendency of an asphalt to oxidize and to lose its ductility and penetration. Asphaltic cement which has no ductility after this volatilization test will not be satisfactory for paving purposes.

Ductility is the measure of the ability of an asphaltic cement to expand and contract without breaking or cracking. The same asphalt at a higher penetration should have a higher ductility, so all ductility tests should be based on a certain definite penetration regardless of the temperature, or should be based upon a temperature of 32°F. Ductility is also a measure of the cementing strength.

Viscosity is a measure of ability of the asphaltic cement to impart plasticity and malleability.

EFFECT OF MINERAL MATTER ON THE PENETRATION OF ASPHALTIC CEMENT (Typical Case).

% Dust	Penetration	Melting Point
0	200	100
35	128	110
55	92	120
70	34	150

In a general way, 1% of dust in asphaltic cement decreases the penetration 2 points with A.C. of ordinary penetration. This will vary somewhat according to the character of the asphaltic cement. A pavement having a relation of 2 parts dust and 1 part bitumen cannot soften or flow in hot weather.

FLUXING OF HARD ASPHALT

As a general rule, 30% of 10—12°Be' asphaltic flux is required to bring Trinidad asphalt to a penetration of 50. Less of paraffin flux is required. For each 1% of asphaltic flux added to about 50° asphalt the penetration is raised 3 points. For exact results a test should be made with the actual materials in question.

Composition of Asphalt Pavements

The following table gives a comparison of a typical composition and properties of good mixtures representing the various types of asphalt wearing surface pavements.

	Bituminous Concrete (Topeka Spec.)	Bituminous Concrete (Warren)	Sheet Asphalt	Bituminous Earth "National"
Asphaltic cement	8.0%	6.0%	10.0%	20.0%
Dust passing 200 mesh screen	12.0	5.5	12.0	62.0
Dust passing 80 mesh screen	12.0	2.8	16.0	15.0
Dust passing 40 mesh screen	20.0	6.7	38.0	3.0
Dust passing 10 mesh screen	20.0	24.5	24.0	0.0
Dust passing 4 mesh screen	18.0	15.3	0.0	0.0
Dust passing 2 mesh screen	10.0	13.3	0.0	0.0
Dust passing 1 mesh screen	0.0	25.0	0.0	0.0
	100.0	100.0	100.0	100.0
Weight per sq. yd. 2 in. surface	215 lbs.	225 lbs.	205 lbs.	185 lbs.

SHEET ASPHALT PAVEMENT.

Sheet asphalt is the standard asphalt pavement. Specifications call for two courses of the following composition and properties.

BINDER OR BOTTOM COURSE.

	Limits	Standard
Bitumen	5½%— 8%	6.0%
Mineral passing 200 mesh	7 —12	8.0
Mineral passing 80 mesh	10 —20	12.0
Mineral passing 40 mesh	10 —20	15.0
Mineral passing 10 mesh	7 —20	13.0
Mineral passing 4 mesh	10 —20	17.0
Mineral passing 2 mesh	10 —20	16.0
Mineral passing 1 mesh	10 —20	13.0
		100.0
Thickness		1½ in.
Density		over 2.30

TOP COURSE.

	Limits	Standard
Bitumen	9.75%—11.0%	10.0%
Mineral passing 200 mesh	12 —18	13.0
Mineral passing 80 mesh	20 —34	23.0
Mineral passing 40 mesh	20 —40	27.5
Mineral passing 10 mesh	12 —35	26.5
Mineral passing 4 mesh	0	0.0
Mineral passing 2 mesh	0	0.0
Mineral passing 1 mesh	0	0.0
		100.0
Thickness		1½ in.
Density		over 2.17

RELATION OF THE DEFECTS OF AN ASPHALT PAVEMENT TO ITS PHYSICAL PROPERTIES.

Cracking is caused by asphaltic cement without sufficient ductility, with too low penetration, insufficient in quantity or that has been over-heated; Imperfections in the base, such as a cracking in the base or the lack of a rigid base or lateral support; Insufficient compression when laid; Lack of traffic.

Disintegration and Hole Formation are caused by asphaltic cement with poor ductility and cementing value, or insufficient to coat mineral aggregate and fill voids; Dirty sand; Non-uniform thickness of surface mixture; Weak foundations in spots; Water from beneath.

Scaling of the Surface Mixture is caused by asphaltic cement lacking in cementing power, insufficient in quantity or subject to decomposition by the weather; Improper grading of mineral, particularly insufficient dust; Dirt conglomerates in sand; Insufficient density.

Waviness and Displacement are caused by asphaltic cement without cementing power, too soft or in too large quantity; Irregularity of surface thickness, or of composition of asphaltic surface mixture; Insufficient dust or filler; Non-rigid base or expansion of the base; Street with heavy grade.

Marking is caused by asphaltic cement that is too soft or in too large quantity; Sand that is too uniform; Insufficient dust or filler; Insufficient density.

FUNCTIONS OF VARIOUS CONSTITUENTS OF ASPHALTIC SURFACE MIXTURE.

Gravel and Coarse Sand in proper relation diminish voids, insure greater stability and increase density, allow the use of less asphaltic cement, decrease tendency to displacement, waviness and marking, increase susceptibility to damage by erosion and abrasion.

Sand in proper relation increases stability by filling voids in stone, increases capacity to resist abrasion, diminishes tendency to raveling.

Filler or Very Fine Dust in proper relation increases density and stability by filling voids in sand, increases capacity to resist abrasion, allows wider range in penetration of A.C., diminishes or overcomes tendency to marking, displacement and waviness, increases cementition of mixture, increases capacity for A.C., increases the need for much compression and softer A.C. in laying mixture, eliminates lakes of A.C., decreases brittleness of pavement.

A.C. in proper quantity and relation cements mineral particles together, keeps out water, imparts pliability, resiliency and noiselessness, prevents erosion and disintegration of coarse mineral of pavement.

MATERIALS REQUIRED FOR 1000 YARDS OF ASPHALTIC CONCRETE PAVEMENT ARE AS FOLLOWS: (Typical)

For concrete base (6 inches of 1:3:6 mix)

Cement	=	732 sacks=183 barrels
Sand	=	77 cubic yards
Rock	=	155 cubic yards
Water	=	7,000 gallons

For wearing surface

"Chats" or Gravel	=	32 tons
Sand (Coarse)	=	32 tons
Sand (Fine)	=	32 tons
Dust	=	7 tons
Asphaltic cement	=	8½ tons

U. S. Patents on Petroleum Refining

Inventor	Number	Date	Subject
Adair, T. D.	1,106,352	Aug. 4, 1914	Gasoline and water separator
Adams, J. H.	976,975	Nov. 29, 1910	Oil-converting process
Alexander, C. M.	1,230,975	June 26, 1917	Process of making aromatic hydrocarbons
Alkemade, Jacob v Rijn v	1,076,000	Oct. 14, 1913	Production of translucent, uniformly-colored paraffin
Allan, D. M., Jr.	1,187,797	June 20, 1916	Refining petroleum
Artmann, Carl	1,031,227	July 2, 1912	Manufacture of asphalt blocks, slabs and the like
Atwood, Luther	28,246	May 15, 1860	Apparatus for distillation of coal oil
Atwood, William	226,151	April 6, 1880	Distillation of oils
Bacon, Brooks & Clark	1,131,309	March 9, 1915	Manufacture of gasoline
Bacon & Clark	1,101,482	June 23, 1914	Treatment of petroleum hydrocarbons
Barnickel, W. S.	1,093,098	April 14, 1914	Process for treating crude oil
Barnickel, W. S.	1,223,659	April 24, 1917	Treatment of crude oil
Barnickel, W. S.	1,223,660	April 24, 1917	Apparatus for treating natural oils and residues of same
Bartels, E.	1,115,887	Nov. 3, 1914	Process of extinguishing fires
Baskerville, Chas.	1,231,985	July 3, 1917	Process of producing a plastic material
Bassett, R. D.	1,120,669	Dec. 15, 1914	Process of recovering and grading gasoline
Bassett, R. D.	1,120,670	Dec. 15, 1914	Apparatus for recovering and grading gasoline
Bates, F. H.	1,046,451	Dec. 10, 1912	Method of generating oil-gas for explosive engines
Baum, E. P.	1,109,103	Sept. 1, 1914	Oil-purifying apparatus
Beckley, R. E.	1,127,722	Feb. 9, 1915	Oil and gas separator
Bell, A. F. L.	1,231,695	July 3, 1917	Apparatus for refining petroleum
Bending, W. P.	998,670	July 25, 1911	Process of treating hydrocarbon oils
Bending, W. P.	1,144,522	June 29, 1915	Apparatus for drying oils
Benham, E. B.	1,040,124	Oct. 1, 1912	Method of and apparatus for converting liquid hydrocarbons into gas or vapor
Benhoff & Jensen	1,181,564	May 2, 1916	Apparatus for distilling hydrocarbons
Benton, Geo. L.	342,564	May 25, 1886	Process for refining crude petroleum oil
Benton, Geo. L.	342,565	May 25, 1886	Apparatus for refining crude petroleum
Berend, Ludwig	1,167,373	Jan. 11, 1916	Process for solidifying emulsion products
Blacher & Sztencel	956,276	April 26, 1910	Process of concentrating and purifying sludge acid
Black, J. C.	968,640	Aug. 30, 1910	Refining petroleum
Black, J. C.	1,152,478	Sept. 7, 1915	Refining petroleum
Black, J. C.	1,164,162	Dec. 14, 1915	Refining petroleum
Blowski & Blowski	1,186,373	June 6, 1916	Process for treating sulfuric-acid residues
Born, Sidney	1,234,124	July 24, 1917	Petroleum-distilling aparatus
Borrmann, C. H.	1,220,067	March 20, 1917	Process and apparatus for continuously distilling mineral oils and the like
Bower, H.	230,171	July 20, 1880	Process and apparatus for treating residuum from petroleum refineries
Breinig, R. M.	306,897	Oct. 21, 1884	Process of the treatment of sludge acid
Brooks, Essex & Smith	1,191,916	July 18, 1916	Process and apparatus for chlorination
Brooks & Smith	1,231,123	June 26, 1917	Production of chlorinated hydrocarbons
Brown, A. L.	1,234,862	July 31, 1917	Treatment of hydrocarbon oils

U. S. PATENTS ON PETROLEUM REFINING—Continued

Inventor	Number	Date	Subject
Brown, Ernest	1,225,569	May 8, 1917	Apparatus for treating heavy oils
Brown, L. W.	994,100	May 30, 1911	Process of breaking up and separating gaseous liquid and solid constituents of crude petroleum
Brucke, Otto	963,510	July 5, 1910	Apparatus for the purification of oils and similar bodies
Bursch, Eli N.	1,238,101	Aug. 28, 1917	Plastic lubricating compounds
Burdon, J., W. M. and M. M.	1,112,051	Sept. 24, 1914	Oil gas producer
Burrows, H. G.	998,837	July 25, 1911	Process of refining oil
Burton, W. M.	1,055,707	March 11, 1913	Process of producing asphalt
Burton, W. M.	1,049,667	Jan. 7, 1912	Manufacture of gasoline
Burton, W. M.	1,105,961	Aug. 4, 1914	Manufacture of gasoline
Burton, W. M.	1,112,113	Sept. 29, 1914	Process of producing wax from other hydrocarbons
Burton, W. M.	1,167,884	Jan. 11, 1916	Petroleum product
Byerley, Francis X.	524,130	Aug. 7, 1894	Manufacture of asphalt, etc., from petroleum
Campbell, Andrew	999,628	Aug. 1, 1911	Apparatus for treating paraffin wax
Chamberlain, H. P.	1,221,790	April 3, 1917	Obtaining products from petroleum by decomposition of component hydrocarbons
Cherry, L. B.	1,229,886	June 12, 1917	Synthetic production of hydrocarbon compounds
Clark, Edward	232,685	Sept. 28, 1880	Recovering sulphuric acid from sludge acid
Clark, Edgar M.	1,119,496	Dec. 1, 1914	Method of distilling petroleum
Clark, Edgar M.	1,129,034	Feb. 16, 1915	Art of petroleum distillation
Clark, Edgar M.	1,132,163	March 16, 1915	Art of petroleum distillation
Clark, C. E.	1,147,608	July 20, 1915	Gas generating system
Coast, John W., Jr.	1,250,798	Dec. 18, 1917	Art of distilling hydrocarbons
Coast, John W., Jr.	1,250,801	Dec. 18, 1917	Art of cracking petroleum hydrocarbons
Coast, John W., Jr.	1,252,401	Jan. 8, 1918	Art of distilling hydrocarbons
Cobb, J. O.	1,201,558	Oct. 17, 1916	Gasoline separator
Collins, Jacob	1,028,439	June 4, 1912	Process of treating petroleum
Cook & Price	1,190,633	July 11, 1916	Process for the separation of asphaltic compounds from gangue
Cornell, S.	1,202,969	Oct. 31, 1916	Process and device for separation of oils
Cosden, J. S.	981,176	Jan. 10, 1911	Oil distilling and refining apparatus
Cottrell & Speed	987,115	March 31, 1911	Separating and collecting particles of one liquid suspended in another liquid
Cottrell & Wright	987,117	March 21, 1911	Separating and collecting particles of one liquid suspended in another liquid
Cottrell & Speed	987,116	March 21, 1911	Apparatus for separating and collecting particles of one liquid suspended in another liquid.
Cottrell, F. G.	987,114	March 21, 1911	Process for separating and collecting particles of one liquid suspended in another liquid.
Crane, Frederick C.	1,223,153	April 17, 1917	Method or process of treating liquids
Cronenberger, W. M.	1,152,399	Sept. 7, 1915	Separator and filter
Cross, Walter M.	1,203,312	Oct. 31, 1916	Process of treating hydrocarbons and products derived therefrom
Cross, Roy	1,255,138	Feb. 5, 1918	Method of refining petroleum

U. S. PATENTS ON PETROLEUM REFINING—Continued

Inventor	Number	Date	Subject
Culmer, G. F. and G. C. K.	635,429	Oct. 24, 1899	Process of making asphaltic fluxes
Culmer, G. F. and G. C. K.	635,430	Oct. 24, 1899	Asphaltic flux
Danckwardt, P.	1,141,529	June 1, 1915	Process for the production of gasoline and naptha from crude oil, petroleum products, tar oil or similar products
Davidson & Ford	1,229,042	June 5, 1917	Process for improving the quality and yield of hydrocarbon gases
Davidson, S.	1,238,644	Aug. 28, 1917	Process for making gasoline
Davis, J. T.	1,159,186	Nov. 2, 1915	Method of and apparatus for distilling oil
Day, D. T.	826,089	July 17, 1906	Process of refining and purifying hydrocarbon oils
Day, D. T.	1,004,632	Oct. 3, 1911	Apparatus for treating hydrocarbon oils
Day, D. T.	1,221,698	April 3, 1917	Process of treating mineral oils for increasing the yield of light gravity oils
Dayton, W. C.	1,174,971	March 14, 1916	Process of making gas
Dayton, W. C.	1,174,970	March 14, 1916	Apparatus for making gas from liquid hydrocarbons
Dehnst, J.	1,112,602	Oct. 6, 1914	Process of treating mineral oils
Dewar & Redwood	419,931	Jan. 21, 1890	Process of distilling mineral oils and like products
Dewar & Redwood	426,173	April 22, 1890	Apparatus for the distillation of mineral oils and like products
Dubbs, J. A.	1,002,570	Sept. 5, 1911	Treatment of petroleum
Dubbs, J. A.	1,057,227	March 25, 1913	Treating petroleum and petroleum residues
Dubbs, J. A.	1,100,717	June 23, 1914	Treating oil
Dubbs, J. A.	1,123,502	Jan. 5, 1915	Treating oil
Dubbs, J. A.	1,135,506	April 13, 1915	Treatment of petroleum
Dubbs, C. P.	1,231,509	June 26, 1917	Method for treating petroleum and other hydrocarbons
Dundas, R. C.	1,056,980	March 25, 1913	Process of making asphalt
Dundas, R. C.	1,120,039	Dec. 8, 1914	Distilling apparatus
Dunham, F. H.	1,003,040	Sept. 12, 1911	Apparatus for and method of treating asphalt solutions for the production of asphalt cement and the recovery of the lighter products
Dunham, F. H.	1,013,283	Jan. 2, 1912	Method of and apparatus for treating asphaltic oils for the production of asphalt and the recovery of lighter products
Dyer, E. I.	1,207,381	Dec. 5, 1916	Method of dehydrating and refining hydrocarbon oils
Dyer, E. I.	1,220,504	March 27, 1917	Apparatus for dehydrating hydrocarbon oils
Earle, G. W.	1,221,038	April 3, 1917	Method of preventing or extinguishing fires in oil tanks
Edeleanu, L.	911,553	Feb. 2, 1909	Process for purifying crude petroleum and its distillates
Eggleston, J. E.	1,018,040	Feb. 20, 1912	Utilizing sulfur containing petroleum
Eldred & Mersereau	1,234,886	July 31, 1917	Process of making unsaturated hydrocarbons
Ellott, W. S.	1,242,667	Oct. 9, 1917	Oil purifying system
Ellis, C.	1,089,359	March 3, 1914	Treating petroleum oils with ultra-violet light
Ellis, C.	1,191,880	July 18, 1916	Organic chemical process
Ellis, C.	1,216,971	Feb. 20, 1917	Treating oils, etc.
Emory, F. F.	1,148,834	Aug. 3, 1915	Oil filter
Erwin & Erwin	1,085,805	Feb. 3, 1914	Process of extinguishing fires in oil tanks

U. S. PATENTS ON PETROLEUM REFINING—Continued

Inventor	Number	Date	Subject
Eva, Gray & Christy	1,100,126	June 16, 1914	Process of and apparatus for aerating and feeding liquid fuel
Ewing, C. R.	1,083,998	Jan. 13, 1914	Apparatus for distilling petroleum
Fagan, John G.	1,148,763	Aug. 3, 1915	Method of extinguishing fire
Fales, Levi S.	97,182	Nov. 23, 1869	Improved mode of recovering the spent acid from oil refineries
Fazi, R. de	1,108,351	Aug. 25, 1914	Motor spirit
Felizat, L.	1,070,435	Aug. 19, 1913	Process of extracting oils from fuller's earth and like materials
Felten, D. F.	1,179,296	April 11, 1916	Oil gas generator
Farrar & Gill	206,309	July 23, 1878	Process and apparatus for recovering waste sulphuric acid
Fleming, J. C.	956,065	April 26, 1910	Apparatus for refining oil
Forrest, Chas. N.	1,163,593	Dec. 7, 1915	Manufacture of asphalt cement from natural asphalts
Forward, C. B.	1,189,083	June 27, 1916	Process of treating crude petroleum
Forward, C. B.	1,181,301	May 2, 1916	Method of treating crude oil
Forward, C. B.	1,202,823	Oct. 31, 1916	Process of reducing crude petroleum
Forward, C. B.	998,569	July 18, 1911	Process for the manufacture of asphalt
Forward, C. B.	1,100,966	June 23, 1914	Apparatus for fractioning mineral oils
Forward, C. B.	1,088,693	March 3, 1914	Apparatus for continuously distilling crude oil and other substances
Forward, C. B.	1,088,692	March 3, 1914	Process for the manufacture of asphalt from crude mineral oil or residuum thereof
Franke, A. H.	1,142,512	June 8, 1915	Apparatus for purifying oil
Frasch, Hans A.	1,212,620	Jan. 16, 1917	Method of and apparatus for distilling hydrocarbons
Frasch, Herman	845,735	Feb. 26, 1907	Steam still for petroleum
Frasch, Herman	968,760	Aug. 30, 1910	Obtaining petroleum products
Frasch, Herman	951,729	March 8, 1910	Apparatus for use in obtaining petroleum products
Frasch, Herman	951,272	March 8, 1910	Obtaining petroleum products
Frasch, Herman	378,246	Feb. 21, 1888	Refining Canadian and similar petroleum oils
Gallsworthy, Benj.	1,234,327	July 24, 1917	Still
Garrity, W. F. and Jarvis	1,190,538	July 11, 1916	Process for purifying oil
Gay, Cassius M.	1,179,001	April 11, 1916	Process and apparatus for recovering volatile hydrocarbons from crude oil
Gellen, A.	1,063,025	May 27, 1913	Apparatus for the recovery of acid used in refining oils
Gillons, G. H.	1,084,080	Jan. 13, 1914	Oil-refining mechanism
Gray, E. B.	1,005,425	Oct. 10, 1911	Apparatus for concentrating acid
Gray, G. W.	1,193,540	Aug. 8, 1916	Method for converting higher boiling petroleum hydrocarbons into lower-boiling petroleum hydrocarbons
Gray, G. W.	1,193,541	Aug. 8, 1916	Method for converting higher boiling petroleum hydrocarbons into lower-boiling petroleum hydrocarbons
Gray, J. L.	923,429	June 1, 1909	Process of separating acid from petroleum sludge
Gray, J. L.	923,428	June 1, 1909	Process of treating petroleum sludge

U. S. PATENTS ON PETROLEUM REFINING—Continued

Inventor	Number	Date	Subject
Gray, J. L.	1,192,889	Aug. 1, 1916	Apparatus for use in connection with the distillation of petroleum
Gray, J. L.	923,427	June 1, 1909	Process of treating petroleum sludge to produce pitch, asphalt, etc.
Gray, T. T.	1,158,205	Oct. 26, 1915	Process of treating hydrocarbon oils
Grant, J. B. and Mason	339,545	April 6, 1886	Process of refining petroleum
Goodaire & Stead	101,003	March 22, 1870	Restoring spent alkali
Greenstreet, C. J.	1,110,924	Sept. 15, 1914	Process of treating heavy hydrocarbon oils
Greenstreet, C. J.	1,110,923	Sept. 15, 1914	Process of treating heavy hydrocarbon oils
Greenstreet, C. J.	1,110,925	Sept. 15, 1914	Process of manufacturing olefins and their oxidation products
Greenstreet, C. J.	1,166,982	Jan. 4, 1916	Apparatus for treating oil
Grousilliers, H. de	378,774	Feb. 28, 1888	Process of treating sludge acid
Guillaume, E.	996,081	June 27, 1911	Process and apparatus for the rectification of crude petroleum and other volatile liquids
Gulick, W. R.	1,187,061	June 13, 1916	Process of making a stable volatile composition suitable for explosive engines
Hall, C. H.	86,535	Feb. 2, 1869	Distilling hydrocarbon oils
Hall, W. A.	1,175,909	March 14, 1916	Process for the conversion of heavy hydrocarbons into lighter hydrocarbons
Hall, W. A.	1,242,796	Oct. 9, 1917	Producing motor fuel
Hall, W. A.	1,105,772	Aug. 4, 1914	Process of making gas from oil
Hall, W. A.	1,194,289	Aug. 8, 1916	Process of cracking hydrocarbons
Hall, W. A.	1,239,100	Sept. 4, 1917	Liquid fuel
Hall, W. A.	1,239,099	Sept. 4, 1917	Hydrocarbon products
Hall, W. A.	1,175,910	March 14, 1916	Process of making motor fuel
Hall, W. A.	1,242,795	Oct. 9, 1917	Production of motor spirit from heavy hydrocarbons
Hall, W. A.	1,247,671	Nov. 27, 1917	Distillation of heavy oils, oil residues and bitumens
Hamilton, T. S.	1,018,971	Feb. 27, 1912	Method or process of purifying hydrocarbon liquids
Hansen, J.	1,084,738	Jan. 20, 1914	Process for expressing fluid from paraffin compositions
Hastings & Brink	867,505	Oct. 1, 1907	Gas cooling and gasoline separating apparatus
Hennebutte, H.	1,165,878	Dec. 28, 1915	Distillation of hydrocarbons
Hennebutte, H.	1,165,877	Dec. 28, 1915	Refining petroleum
Hense, Rudolph	1,073,233	Sept. 16, 1913	Process for obtaining a charge liquid particularly adapted for explosion motors from liquid hydrocarbons
Herber, Sam M.	1,111,580	Sept. 22, 1914	Oil distillation
Herber, Sam M.	1,183,457	May 16, 1916	Oil distillation
Hirschberg, L.	1,042,915	Oct. 29, 1912	Process for manufacturing oils soluble in water
Hirt, L. E.	1,222,402	April 10, 1917	Method and apparatus for fractioning hydrocarbons
Hirt, L. E.	1,250,879	Dec. 18, 1917	Method and apparatus for fractioning hydrocarbons
Holmes & Blasdell	1,055,747	March 11, 1913	Apparatus for refining petroleum
Hood & Salamon	962,840	June 28, 1910	Treatment of mineral and vegetable oils
Hopkins, A. S.	1,199,463	Sept. 26, 1916	Process of distilling petroleum

U. S. PATENTS ON PETROLEUM REFINING—Continued

Inventor	Number	Date	Subject
Hopkins, A. B.	1,199,464	Sept. 26, 1916	Apparatus for distilling petroleum oils
Huglo, V.	953,952	April 5, 1910	Distillation of heavy and residual oils of petroleum
Humphreys, R. E.	1,122,002	Dec. 22, 1914	Petroleum-distilling apparatus
Humphreys, R. E.	1,122,003	Dec. 22, 1914	Process of distilling petroleum
Humphreys, R. E.	1,119,700	Dec. 1, 1914	Method of distilling hydrocarbons
Hyde, J. B.	281,999	July 24, 1883	Insulating compound for electrical conductors and apparatus for compounding and applying same
Holmes, J. E.	1,241,979	Oct. 2, 1917	Process of and apparatus for producing light hydrocarbons
Ilges, F. W.	968,478	Aug. 23, 1910	Apparatus for the uninterrupted separation of constituents
Jenkins, U. S.	1,226,526	May 15, 1917	Method of obtaining gasoline and other light oils from heavier hydrocarbons
Jones & Jones	1,089,926	March 10, 1914	Apparatus for manufacturing gas
Jones & Jones	1,157,225	Oct. 19, 1915	Method of manufacturing illuminating gas from liquid hydrocarbons
Jones, R. G.	1,166,375	Dec. 28, 1915	Apparatus for refining petroleum
Jones, R. G.	1,005,977	Oct. 17, 1911	Method of and means for separating crude petroleum from moisture, bases and sand
Kasson & Saxton	998,691	July 25, 1911	Liquid bituminous compound and process of making same
Kelsey, S. E.	1,092,366	April 7, 1914	Still or retort
Kendall, E. D.	1,192,529	July 25, 1916	Process for extracting light liquefiable hydrocarbons from natural gas
Kendall, E. D.	1,154,517	Sept. 21, 1915	Apparatus for refining hydrocarbons
Kendall, E. D.	1,154,516	Sept. 21, 1915	Process of refining hydrocarbons
Kerr, A. N.	1,199,903	Oct. 3, 1916	Refining method and apparatus
Kirschbraun, L.	1,194,750	Aug. 15, 1916	Asphaltic products and process of making same
Kitchen, J. M. W.	1,008,273	Nov. 7, 1911	System for distillation
Knottenbelt, H. W.	1,194,033	Aug. 8, 1916	Process of treating petroleum and shale oils
Koehler & Link	1,084,016	Jan. 13, 1914	Distilling petroleum
Koppers, H.	1,098,734	June 2, 1914	Fractional distillation of oil substances
Lackman, A.	1,171,524	Feb. 15, 1916	Apparatus for distilling mineral oils
Laing, J.	471,291	March 22, 1892	Apparatus for the destructive distillation of mineral oils
Laird & Raney	1,116,299	Nov. 3, 1914	Process of treating petroleum emulsions
Laird & Raney	1,142,761	June 8, 1915	Apparatus for dehydrating petroleum oil
Laird & Raney	1,142,760	June 8, 1915	Apparatus for treating emulsions
Laird & Raney	1,142,759	June 8, 1915	Treater for petroleum emulsions
Lamplough, F.	1,229,098	June 5, 1917	Process and apparatus for the conversion of heavy hydrocarbons into lighter hydrocarbons
Landes, W.	1,199,909	Oct. 3, 1916	Process for producing a new motor spirit
Landsberg, Ludwig	1,211,721	Jan. 9, 1917	Process for the manufacture of asphalt-like masses and derivatives therefrom
Lang, Jas. S.	954,575	April 12, 1910	Apparatus for distilling hydrocarbon oils
Lasher, D. F.	1,075,481	Oct. 14, 1913	Process for refining and purifying oils

U. S. PATENTS ON PETROLEUM REFINING—Continued

Inventor	Number	Date	Subject
Linderborg & Scott	1,220,651	March 27, 1917	Process and apparatus for obtaining hydrocarbons from gases
Livingston, Max	728,257	May 19, 1903	Apparatus for continuously distilling petroleum
Loftus, Robt. G.	43,157	June 14, 1864	Improved process of recovering acid used in refining petroleum
Low, F. S.	1,192,653	July 25, 1916	Process of making gasoline
Lucas, O. D.	1,168,404	Jan. 18, 1916	Process of manufacturing catalytic bodies
Lucas, O. D.	1,183,091	May 16, 1916	Treating oils
Lambert, C. G.	1,245,930	Nov. 6, 1917	Apparatus for cracking oils
Maag, G. C.	1,142,525	June 8, 1915	Apparatus for obtaining liquid hydrocarbons
Maitland, H. T.	1,188,961	June 27, 1916	Process of refining lubricating oils
Mann, F. W.	619,593	Feb. 14, 1899	Apparatus for distilling petroleum
Mann & Chappell	1,163,025	Dec. 7, 1915	Process for refining petroleum and its products
Mann & Chappell	1,183,094	May 16, 1916	Process for making chlorinated hydrocarbons
Mann & Chappell	1,214,204	Jan. 30, 1917	Process for the production of aromatic bodies and gas from petroleum oils
Mann & Chappell	1,249,444	Dec. 11, 1917	Apparatus for manufacture of aromatic bodies from petroleum oils
Martini, Dan	892,378	June 30, 1908	Method of treating cold crude petroleum or distillate thereof to obtain an explosive mixture for internal-combustion engines
Mijs, Jan	1,178,532	April 11, 1916	Process of obtaining ceresin and the like from residues of mineral oil
Miles, G. W.	1,168,534	Jan. 18, 1916	Emulsified paraffin wax and process of making same
Mills, E. N.	1,007,788	Nov. 7, 1911	Means for transporting oil
Mitchell, Willis	1,141,072	May 25, 1915	Gas generator
Montague, H. E.	1,127,551	May 22, 1917	Internal-combustion engine
Mooney, L.	1,174,888	March 7, 1916	Process of and apparatus for removing deposits from crude oil stills
Moore, J. B.	1,130,318	March 2, 1915	Apparatus for distilling petroleum oils
Morris, W. L.	1,137,075	April 27, 1915	Filter
McAfee, A. M.	1,099,096	June 2, 1914	Manufacture of aluminum chlorid
McAfee, A. M.	1,127,465	Feb. 9, 1915	Process of improving oils
McAfee, A. M.	1,144,304	June 22, 1915	Manufacture of aluminum chlorid
McAfee, A. M.	1,202,081	Oct. 24, 1916	Recovery of aluminum chloride
McAfee, A. M.	1,235,523	July 31, 1917	Process of treating oils
McArthur, D. R.	1,119,974	Dec. 8, 1914	Method of making a hydrocarbon liquid suitable for use in internal-combustion engines
McHenry, C. D.	1,154,869	Sept. 28, 1915	Gas-generating apparatus
McKissack, R. I.	1,113,029	Oct. 6, 1914	Liquid fuel gas generator
Neal, S.	1,036,306	Aug. 20, 1912	Distillation process
Nikiforoff, A.	755,309	March 22, 1904	Manufacture of the benzols and their homologues
Noad, J.	971,468	Sept. 27, 1910	Treatment of hydrocarbon oils and the like

U. S. PATENTS ON PETROLEUM REFINING—Continued

Inventor	Number	Date	Subject
Noad, J.	985,053	Feb. 21, 1911	Apparatus for distilling shale and other bituminous substances
Nordensson, C. O.	1,218,575	March 6, 1917	Oil-gas producer
Olsen, Geo. E.	1,199,491	Sept. 26, 1916	Apparatus for cleaning and purifying used gasoline, naphtha or the like
Opl, K.	1,128,494	Feb. 16, 1915	Process for the fractional separation of paraffin and like substances and of mixtures of such substances with oil
Palmer, C. S.	1,187,380	June 13, 1916	Process of treating petroleum residues
Parker, J. H.	958,820	May 24, 1910	Process for the treatment of oil
Parker, W. M.	1,226,990	May 22, 1917	Process for refining oils
Penissat, Andre	204,244	March 7, 1878	Improvement in processes for recovering waste sulphuric acid
Peterson, F. P.	1,031,664	July 2, 1912	Art of the condensation of gases or vapors into their liquid forms
Petroff, Grigori	1,087,888	Feb. 17, 1914	Process for the extracting and separating sulfo-acids from crude petroleum hydrocarbons and acid residues
Petroff, Grigori	1,233,700	July 17, 1917	Process of treating mineral oils
Pictet, R. P.	1,228,818	June 5, 1917	Manufacture of carbon monoxid and hydrogen
Pijzel, D.	1,070,730	Aug. 19, 1913	Apparatus for sweating crude paraffin wax or like mixtures of substances which melt at different temperatures
Pine & Ruggles	1,057,667	April 1, 1913	Art of treating asphalt
Porges & Neumann	1,017,587	Feb. 13, 1912	Apparatus for cooling paraffin or the like
Puning, F.	1,176,094	March 21. 1916	Apparatus for recovering hydrocarbons from absorbing oils
Pyzel, D.	1,040,408	Oct. 8, 1912	Process for sweating crude paraffin wax or like mixtures (compositions) of substances which melt at different temperatures
Prutzman, P. W.	1,238,331	Aug. 28, 1917	Apparatus for dehydrating oils
Rensink, G. C.	1,134,419	April 6, 1915	Oil separator and purifier
Reynolds, F. R.	1,119,453	Dec. 1, 1914	Oil refiner
Richter, Felix	1,098,763	June 2, 1914	Process for purifying hydrocarbons
Richter, Felix	1,098,764	June 2, 1914	Process for the purification of liquid hydrocarbons
Rites, F. M.	1,167,021	Jan. 4, 1916	Apparatus for producing gaseous fuel
Rites, F. M.	1,144,788	June 29, 1915	Apparatus for producing gaseous fuel
Rites, F. M.	1,144,789	June 29, 1915	Process for producing gaseous fuel
Roberts & Emory	1,016,958	Feb. 13, 1912	Method of transporting oil long distances
Robinson, C. I.	1,014,520	Jan. 9, 1912	Utilizing acid sludge from refining petroleum
Robinson, C. I.	1,018 374	Feb. 20, 1912	Utilizing sulphur containing petroleum
Robinson, C. I.	968,692	Aug. 30, 1910	Refining petroleum
Robinson, C. I.	910,584	Jan. 26, 1909	Desulphurizing lima or analogous petroleum and related oils

U. S. PATENTS ON PETROLEUM REFINING—Continued

Inventor	Number	Date	Subject
Rodman, Hugh	1,209,336	Dec. 19, 1916	Process of manufacturing carburizing material and oil distillates
Rogers & Cook	1,122,220	Dec. 22, 1914	Means for controlling still pressure in gasoline manufacture
Rogers, M. C.	1,148,990	Aug. 3, 1915	Oil filtering or purifying device
Rosen, J.	1,165,909	Dec. 28, 1915	Process of the manufacture of lubricating oils and the like
Rosen, J.	1,162,654	Nov. 30, 1915	Process of distillation of heavy oils
Ross & Schofield	1,204,492	Nov. 14, 1916	Apparatus for the distillation of oils
Roth & Venturino	1,208,378	Dec. 12, 1916	Process for the conversion of heavy products of petroleum
Roth & Venturino	1,208,214	Dec. 12, 1916	Apparatus for converting the heavy products obtained from petroleum
Robertson, J. H.	1,238,339	Aug. 28, 1917	Art of producing and treating hydrocarbon vapors during distillation of the same
Rowlands, P. O.	1,252,955	Jan. 8, 1918	Apparatus for vaporizing hydrocarbons
Sabatier & Mailhe	1,152,765	Sept. 7, 1915	Process of converting petroleums and other heavy liquid hydrocarbons into volatile hydrocarbons dist. below 150°C
Sabatier & Mailhe	1,124,333	Jan. 12, 1915	Manufacture of light hydrocarbons or the like
Sampson & Woods	1,177,816	April 4, 1916	Crude oil still
Saybolt, G. M.	989,927	April 18, 1911	Obtaining naphtha from natural gas
Schildhaus & Condrea	956,184	April 26, 1910	Process of obtaining sulphurous acid from acid sludge
Seidenschnur & Dehnst	1,162,729	Nov. 30, 1915	Process of treating crude petroleum
Shaw, F. D.	1,098,412	June 2, 1914	Apparatus for generating gas
Sherman, L. O.	968,088	Aug. 23, 1910	Method of distilling liquids
Snee, J. A.	1,165,458	Dec. 28, 1915	Process for retaining the lighter or more volatile oils contained in the product of oil wells, etc.
Snelling, W. O.	1,056,845	March 25, 1913	Process of refining natural gas gasoline
Snelling, W. O.	1,186,855	June 13, 1916	Process of and apparatus for distillation
Scheuffgen, Robt.	1,118,952	Dec. 1, 1914	Method of extinguishing fires
Schill, E.	1,100,260	June 16, 1914	Process of obtaining liquid hydrocarbons
Schill, E.	1,142,275	June 8, 1915	Apparatus for obtaining liquid hydrocarbons
Seigle, A.	567,751	Sept. 15, 1896	Apparatus for treating liquids
Seigle, A.	567,752	Sept. 15, 1896	Apparatus for treating hydrocarbons
Shiner, O. J.	1,099,622	June 9, 1914	Method of and apparatus for purifying oil
Snelling, W. O.	1,215,732	Feb. 13, 1917	Process of purifying oils
Southey, A. W.	1,120,857	Dec. 15, 1914	Apparatus for the production of gaseous fuel
Stanley, A. M.	1,177,904	April 4, 1916	Gas making apparatus
Starke, E. A.	913,780	March 2, 1909	Producing benzene or its homologues from petroleum
Starke, E. A.	1,109,187	Sept. 1, 1914	Refining petroleum and its by-products
Steenbergh, van B.	1,124,364	Jan. 12, 1915	Process of manufacturing gas
Steinschneider, L.	981,953	Jan. 17, 1911	Apparatus for distilling oils of the petroleum tar and like industries using a high vacuum

U. S. PATENTS ON PETROLEUM REFINING—Continued

Inventor	Number	Date	Subject
Steinschneider, L.	1,192,581	July 25, 1916	Apparatus for distilling petroleum, tar or other substances under vacuum
Stevens, Wm. H.	1,165,462	Dec. 28, 1915	Substitute for gasoline
Stewart, L.	1,163,570	Dec. 7, 1915	Process of and apparatus for distilling petroleum
Still, C.	1,080,177	Dec. 2, 1913	Apparatus for stirring and mixing liquids
Stone, C. W.	1,070,555	Aug. 19, 1913	Process of cleaning and refining oil
Strache & Porges	1,205,578	Nov. 21, 1916	Process for converting heavy hydrocarbons into light hydrocarbons
Suhr, C. L.	1,122,169	Dec. 22, 1914	Distillate condenser and steam generator
Smith, A. D.	1,239,423	Sept. 4, 1917	Manufacture of gasoline
Schwartz, S.	1,247,883	Nov. 27, 1917	Method of treating heavier hydrocarbons
Smith, A. D.	1,239,423	Sept. 4, 1917	Manufacture of gasoline
Tait, E. W.	1,069,908	Aug. 12, 1913	Art or method of making gasoline
Tait, G. M. S.	1,128,549	Feb. 16, 1915	Process of making gas
Testelin & Renard	1,138,260	May 4, 1915	Apparatus for the industrial manufacture of a new spirit by the isomerization of petroleum
Thompson, W. P.	1,160,670	Nov. 16, 1915	Distillation of petroleum
Tienen, van W. O. Th.	1,000,646	Aug. 15 1911	Treatment of acid tar
Timmons, J. R.	1,105,383	July 28, 1914	Apparatus for refining oil
Timmins & Swain	1,179,243	April 11, 1916	Apparatus for refining oil
Travers, W. J.	1,004;219	Sept. 26, 1911	Process of purifying oil
Trumble, M. J.	996,736	July 4, 1911	Evaporator for petroleum oils or other liquids
Trumble, M. J.	1,250,052	Dec. 11, 1917	Double evaporator and process of treating petroleum oils
Trumble, M. J.	1,002,474	Sept. 5, 1911	Apparatus for refining petroleum
Trumble, M. J.	1,070,361	Aug. 11, 1913	Process of refining petroleum or similar oils and apparatus for carrying on this process
Trumble, M. J.	1,182,601	May 9, 1916	Process and apparatus for making asphaltum
Turner, C. W.	1,046,683	Dec. 10, 1912	Apparatus for distilling hydrocarbon oil
Turner, C. W.	151,422	Aug. 24, 1915	Process of distilling hydrocarbon oil
Van Dyke & Irish	1,095,438	May 5, 1914	Process of and apparatus for distilling petroleum
Van Dyke & Irish	1,073,548	Sept. 16, 1913	Process of and apparatus for distilling petroleum
Van Dyke & Irish	1,143,466	June 15, 1915	Process of and apparatus for distilling petroleum
Van Dyke & Irish	1,130,862	March 9, 1915	Fractional condenser for separating hydrocarbons in distilling petroleum

U. S. PATENTS ON PETROLEUM REFINING—Continued

Inventor	Number	Date	Subject
Van Syckel, S.	191,203	May 22, 1877	Continuous distillation and apparatus therefor
Van Vliet & O'Neil	1,094,762	April 28, 1914	Gas generator
Vuilleumier, R.	1,038,691	Sept. 17, 1912	Apparatus for generating high pressure oil gas
Waitz, J. W.	1,105,727	Aug. 4, 1914	Process of producing gasoline
Walker, Henry V.	972,953	Oct. 18, 1910	Solvent for pyroxylin, etc., and process for making same
Walker, Henry V.	955,372	April 19, 1910	Process of desulfurizing petroleum distillates
Waring, R. S.	284,098	Aug. 28, 1883	Insulating material and preparation of same
Waring, W. & Breckenridge	642,578	Feb. 13, 1900	Process of purifying sludge acids
Warren, M. H.	1,110,361	Sept. 15, 1914	Apparatus for refining petroleum
Warth, C. H.	1,131,880	March 16, 1915	Process of making liquid fuel
Washburn, C. H.	1,131,266	May 4, 1915	Process of treating hydrocarbon oils
Weiser, Josef	1,127,951	Feb. 9, 1915	Oil retort
Wells, A. A.	1,232,454	July 3, 1917	Process of decomposing oil
Wells, A. A.	1,187,874	June 20, 1916	Cracking oil
Wells & Wells	877,620	Jan. 28, 1908	Process of refining, fractionating and reducing oils
Welsh, M. J.	1,159,450	Nov. 9, 1915	Earth treating process and product
White, Carter	1,226,041	May 15, 1917	Treatment of mineral oils and residues for the production of lower boiling hydrocarbons
Whitmore, Sam W.	1,125,422	Jan. 19, 1915	Process of refining oils
Willis, G. M.	918,628	April 20, 1909	Process and apparatus for extracting bitumen from bitumen bearing ore.
Wingett, J. N.	1,229,189	June 5, 1917	Apparatus for refining liquid and gases
Wohle, Salo	1,081,801	Dec. 16, 1913	Process of treating petroleum or other hydrocarbon oils
Wolff, Albert	1,240,523	Sept. 19, 1917	Production of sulfonic acid salts from mineral oil waste liquors
Wynne, E. W.	901,411	Oct. 20, 1908	Purifying petroleum oils
Wellman, F. E.	1,245,291	Nov. 6, 1917	Still or retort
Wells, A. A.	1,248,225	Nov. 27, 1917	Process of and apparatus for decomposing hydrocarbon oils
Zerning, H.	1,183,266	May 16, 1916	Process of obtaining gasoline substitute

Chemical Nature of Cracking of Oil

When crude oil is subjected to ordinary distillation by fire the light products naturally present in the oil are distilled off as such up to a temperature of about 300°C (572°F) comprising both the gasoline and the kerosene. Above this temperature the hydrocarbons undergo partial decomposition instead of distilling, with the result that some light products are produced and distilled along with the heavy products. Olefins as well as paraffin compounds of lower molecular weight than the oil being heated are formed. By vigorous firing the entire oil residue may be distilled, leaving only a variable amount of residual carbon as a product of decomposition. The amount of carbon and gas formed by this pyrogenic decomposition is greater with the asphaltic or naphthene petroleums than with the paraffin base petroleums. A typical heavy Mid Continent petroleum gives 4.5% of carbon and 4.0% of gas on distillation to coke or carbon. With pure paraffin base oils the amounts of carbon and gas formed are comparatively slight.

This property of all heavy petroleums in decomposing into hydrocarbons of lower molecular weight by heating is generally known as cracking. The chemical reactions involved in cracking are not extremely definite. It was originally supposed that cracking involved the formation of a large amount of olefins according to the following reaction:

$$C_nH_{2n+2} = C_{n-m}H_{2(n-m)+2} + C_mH_{2m}$$

a specific illustration of which would be

$$C_{15}H_{32} = C_8H_{18} + C_7H_{14}$$

Pentadecane = Octane + Heptylene

This reaction does not, however, accord with the facts, since gas and carbon are always formed in varying amount. A reaction which corresponds to the yields as experimentally found under certain conditions is the following:

$$2C_nH_{2n+2} = 2C_{n-m}\ H_{2(n-m)+2} + mCH_4 + mC$$

or as a specific illustration

$$2C_{15}H_{32} = 2C_8H_{18} + 7CH_4 + 7C$$

Pentadecane = Octane + Methane + Carbon

Yet under certain other conditions the amount of gas formed is very small, indicating that the following reaction was partly carried cut.

$$(2m+2)\quad C_nH_{2n+2} = (2n+2\quad C_mH_{2n+2} + 2(n-m)C$$

or as an illustration

$$9C_{15}H_{32} = 16C_8H_{18} + 7C$$

Pentadecane = Octane + Carbon

This last reaction is also indicated by the yields of gasoline obtained from some crude oils given in the table on page 22.

Pure paraffin wax of melting point of 130°F and specific gravity of 0.892 on repeated cracking confined under pressure up to 57 atmospheres at temperature of 400°C and with a vapor space twice the volume of the liquid, yielded 32.5% by volume of gasoline of 0.724=63.4°Be' gravity or 29.1% by weight by each treatment or a total of 94.7% by weight, or 104% by volume.

The amount produced on first six treatments was as follows:

First	29.1%	by weight of original paraffin
Second	19.9%	by weight of original paraffin
Third	14.5%	by weight of original paraffin
Fourth	9.9%	by weight of original paraffin
Fifth	6.8%	by weight of original paraffin
Sixth	4.7%	by weight of original paraffin
	84.9%	

The gasoline produced consisted of paraffin hydrocarbons as shown in curve on page 105.

CLASSIFICATION OF OIL CRACKING PROCESSES.
(Representative Patents.)

I. Cracking in the vapor phase.
  A Atmospheric Pressure.
    Oil gas plants—very high temperature.
    Pintsch Gas Plants—very high temperature.
    Blaugas Plants—1000-1200°F.
    Parker (W.M.) process—at 1000°F with or without steam.
    Greenstreet—Cherry red with steam.
  B With Increased Pressure.
    Rittman process—above 950°F and 200-300 lbs. pressure.
    W. A. Hall process—1110°F and about 75 lbs. pressure.

II. Cracking in the Liquid Phase.
  A With Distillation.
    1. At Atmospheric Pressure.
      Luther Atwood (1860).
      McAfee Process with aluminum chloride.
      Russian and American Practice for illuminating oils.
    2. Above Atmospheric Pressure.
      Dewar & Redwood (1890).
      Bacon & Clark at 100-300 lbs.
      Burton (Standard Oil Co.) 650-850°F and 60-85 lbs.
      Dubbs, J. A., over 10 lbs. and over 300°F.
    3. Very high pressure (over 27 atmospheres).

B Without Distillation and with High Pressure.

1. Without vapor space for equilibrium (continuous processes).

   Benton (1886) 700-1000°F and 500 pounds.

   Goebel-Wellman.

   Mark (English).

2. With Vapor Space.

   (a) Intermittent.

   Palmer (below 27 atmospheres).

   Snelling.

   (b) Continuous.

CATALYTIC PROCESSES.

Many claims are made as to the virtue of certain substances in promoting the conversion of heavy hydrocarbons into light hydrocarbons. The writer has made many tests with such substances as aluminum chloride, manganese oxide, nickel, copper, lime, mercury, sodium nitrate, aluminum powder, zinc dust, iron dust, iron oxide and platinized pumice and has found in no case either increased rates of reaction or increased yields over those obtained by heat alone under the same conditions.

Electrical processes are not considered by informed refiners on the basis of cost alone and none have yet been demonstrated as having any virtue, in fact, other than as a means of applying heat.

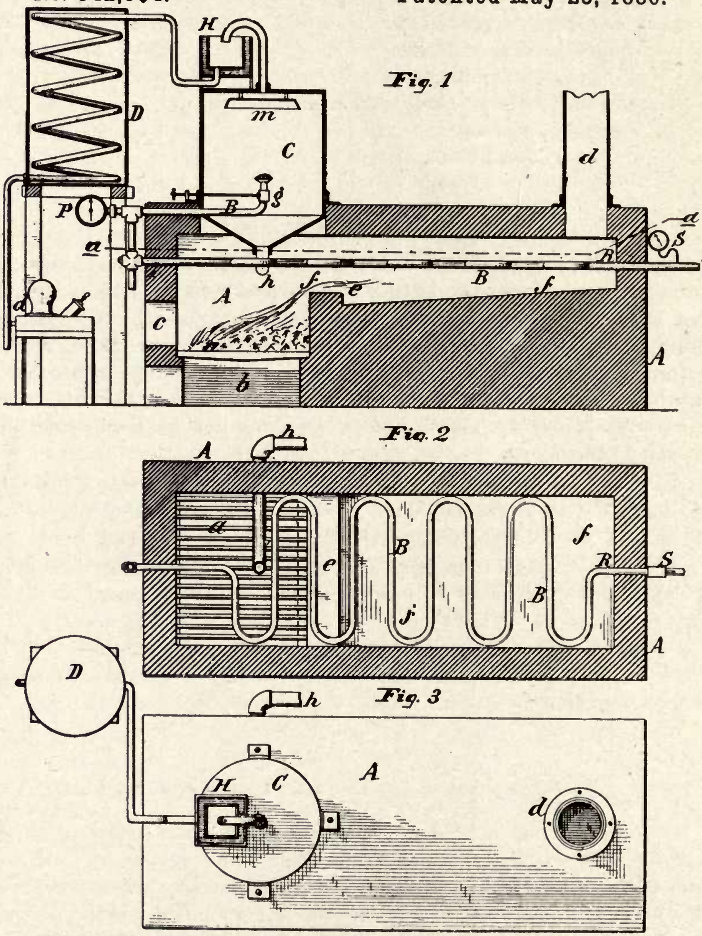
In some instances a sweeter and whiter product resulted by use of added chemicals than with heat alone.

No Model.)

G. L. BENTON.

PROCESS OF REFINING CRUDE PETROLEUM OIL.

No. 342,564. Patented May 25, 1886.



WITNESSES
E. H. Woodruff Jr.
C. A. Woodruff.

INVENTOR
George L. Benton
By J. Walter Douglass
Atty.

Development of Commercial Practice in Cracking of Oil

It has been stated that the commercial cracking of oil was accidentally discovered in the winter of 1861 by a stillman at Newark, New Jersey. However, this is probably not the case, since a patent was granted to Luther Atwood, of New York, May 15, 1860, No. 28,246, in the U. S. Patent Office, which provides for the production of light hydrocarbon illuminating oils from heavy oils, paraffin, etc. The apparatus provides for the cooling of the heavy oil vapors and their return to the still for further cracking. This is all carried out at atmospheric pressure.

The first record of pressure distillation is apparently set forth by James Young in his patent, No. 3345 (English) of 1865, in which a distillation is described as being conducted in a vessel having a loaded valve or a partially closed stop cock through which the confined vapors escape under any desired pressure. Under these conditions, distillation takes place at higher temperature than the normal boiling points of the heavy hydrocarbons and partial cracking results. The patent was taken out for treatment of shale oil and in practice a pressure of 20 pounds to the square inch was recommended.

The first extremely high pressure process was that of Benton, U. S. patent No. 342,564, May 25, 1886. In this the oil is heated at a temperature of from 700 to 1000°F through a pipe not connected with a high pressure vapor chamber, but leading to a low pressure expansion chamber. The pressure used is as high as 500 pounds per square inch.

The most important patent in the present development of cracking processes is that issued to Dewar & Redwood which is described on the following two pages.

SPECIFICATIONS AND CLAIMS OF DEWAR & REDWOOD.

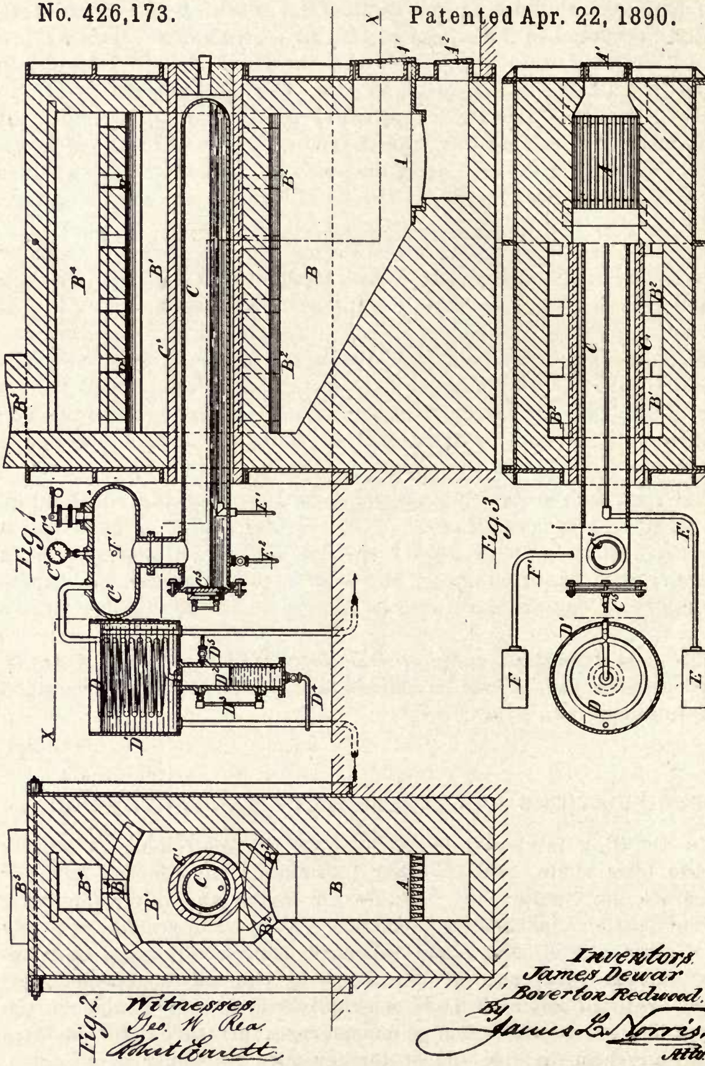
"In distilling mineral oils—such as natural petroleum or similar oil made from shale, coal or other bituminous substances—in order to separate the lighter oils, suitable for lamps and other purposes, from the heavier oils, there is frequently a very large residue of heavy oil. Attempts have been made to obtain lighter oils from such residues or from heavy natural petroleums by causing the vapor generated in the still-boiler to pass a heavily-loaded valve, so that the vaporization takes place under considerable pressure. It has also been proposed to arrange the still-boiler with its upper part cooled,

(No Model.)

J. DEWAR & B. REDWOOD.

APPARATUS FOR THE DISTILLATION OF MINERAL OILS AND LIKE PRODUCTS.

No. 426,173. Patented Apr. 22, 1890.



so that the less volatile portions of the vapor may become more or less condensed and fall back into the hot liquid below, this mode of operating being commonly termed "cracking". Both these methods are objectionable, the former on account of the irregularity of the distillation and the latter on account of the waste of heat in conducting the cracking process and the slowness and insufficiency of the results."

"Our invention relates to a method of conducting the distillation by suitable apparatus in such a manner that we get the benefit of regular vaporization and condensation under high pressure, and that we may at the same time get such advantage as can be obtained from cracking. For this purpose we arrange a suitable boiler or retort, and a condenser in free communication with one another, without interposing any valve between them; but we provide a regulated outlet for condensed liquid from the condenser. We charge and keep charged the space in the boiler or retort and condenser that is not occupied by liquid with gas under considerable pressure, it may be with air or it may be with carbonic-acid gas or other gas that cannot act chemically on the matter treated. The distillation and condensation being thus conducted under considerable pressure, which can be regulated at will, we obtain from the heavy residue a quantity of more or less light oil suitable for illuminating and other purposes, which cannot be obtained by distillation under atmospheric pressure. We may also arrange the still-head or upper part of the boiler or retort so as to operate according to the cracking method above referred to, the cracking in this case taking place under high pressure instead of being carried on under atmospheric pressure.

"The apparatus for effecting distillation in the manner described may be arranged in various ways. The accompanying drawings show one form of apparatus for this purpose.

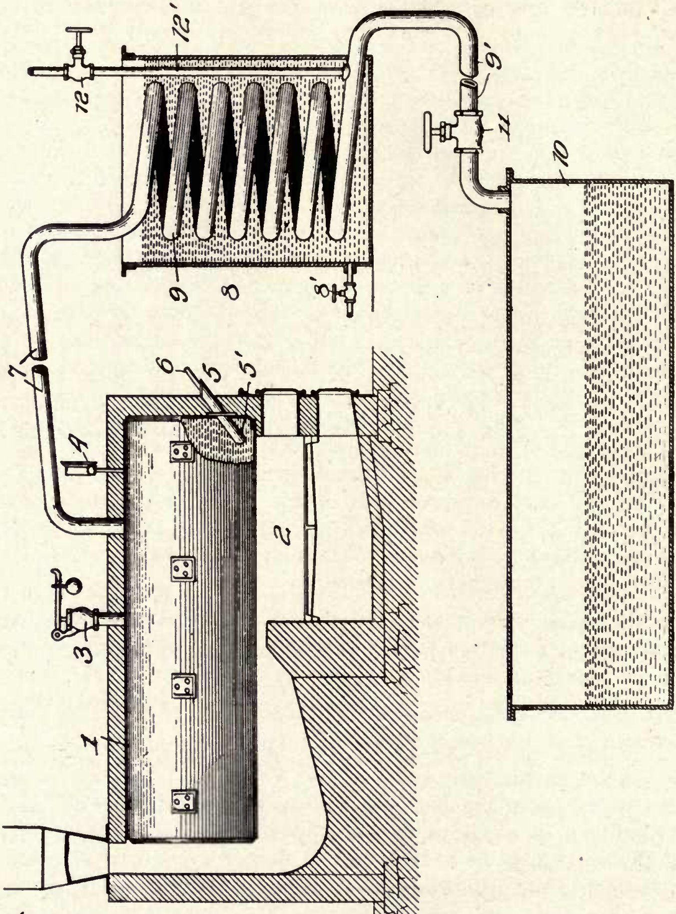
"By a pipe and cock or a suitably loaded safety-valve D^5gas may be withdrawn from the space above the liquid in the column D^2.

"By regulating the heat and pressure to which the retort is subjected the character of the distillate may be varied, and thus oils more or less light can be obtained to suit various uses. Also the proportions of the parts may be varied, and, if necessary, means of cooling may be applied to the still-head C^2.

"Having thus described the nature of our invention and the manner of carrying the same into effect, we claim—the herein-described method of distilling mineral oils and like products, which consists in both vaporizing them and condensing the generated vapor under a regulated pressure of air or gas substantially as specified."

W. M. BURTON.
MANUFACTURE OF GASOLENE.
APPLICATION FILED JULY 3, 1912.

1,049,667. Patented Jan. 7, 1913.



Witnesses.
E. E. Gaylord
G. I. Chase

Inventor:
William M. Burton,
By Dyrenforth, Lee, Chritton & Wiles,
Att'ys.

THE BURTON PROCESS.

This is the process by which much of the artificial gasoline now on the market is made.

The sketch in the patent is shown on the opposite page.

In the practical operation of this process a very hot furnace is required on account of the very great radiation of heat from the return conduit 7.

Novelty in this process is claimed to lie in the maintenance of pressure on the condenser, though this is done in the Dewar & Redwood process already described (q.v.). The fact remains, however, that the Burton process is being successfully operated on a large scale and presumably with profit. In one of the Burton patents (1,105,961) it is claimed that 63½% of the original charge of oil is converted into gasoline.

The actual operation of the Burton process has been described as follows:

The stills have a capacity of 200 barrels each and are heavy, horizontal steel cylinders, with walls one-half inch thick, thoroughly insulated with asbestos. From the top of the still is a long run-back, exposed to the air, which returns for cracking any undecomposed oil. The stills, the run-back and the condenser are all maintained under a pressure of about 85 pounds per square inch, the oil being heated to a temperature of about 750°F. Each still is charged every 48 hours, the yield being 57% of 51° naphtha. The carbon tends to be of a granular or mealy nature, rather than hard and adherent, and is cleaned out after each run.

Important modifications of the Burton process are shown in the Clark patents, 1,119,496, 1,129,034 and 1,132,163; A. S. Hopkins, 1,199,-464; R. E. Humphreys, 1,122,002, 1,122,003 and 1,119,700.

One of the Clark modifications allows the application of heat to tubes and seeks to overcome the danger of heating a large bulk of oil directly.

The Hopkins patent provides for introducing fresh oil supply into the run-back 7.

One of the Humphreys patents provide for plates in the bottom of the still to prevent the bad effect of carbon and to give a large metallic heating area.

The original Burton claims are as follows, (Patent 1,049,667, filed July 3, 1912).

"1. The method of treating the liquid portions of the paraffin series of petroleum distillation having a boiling point upward of 500°F to obtain therefrom low-boiling point products of the same series, which consists in distilling at a temperature of from about 650 to about 850°F

the volatile constituents of said liquid conducting off and condensing said constituents and maintaining a pressure of from about 4 to about 5 atmospheres on said liquid of said vapors throughout their course to and while undergoing condensation.

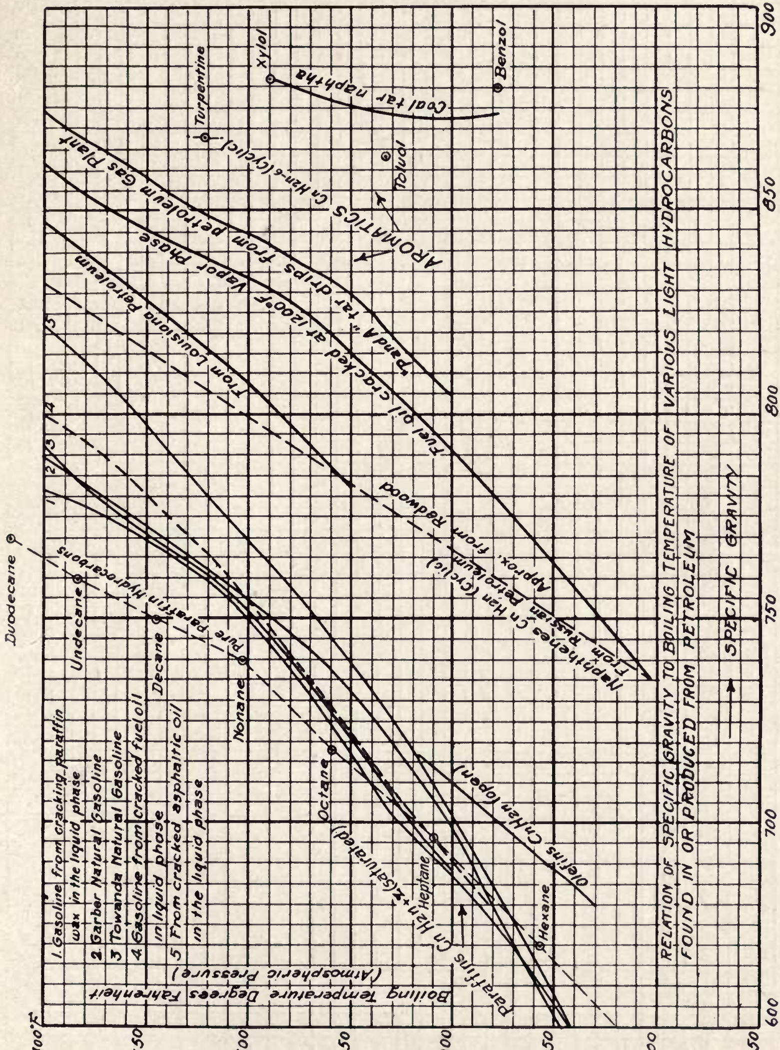
2. The method of treating the liquid portions of the paraffin series of petroleum distillation having a boiling point of upward of 500°F to obtain therefrom low-boiling point products of the same series, which consists in distilling off at a temperature of from about 650 to 850°F the volatile constituents of said liquid, conducting off and condensing said constituents, maintaining a pressure of from about 4 to about 5 atmospheres on said liquid of said vapors throughout their course to and while undergoing condensation, and releasing from time to time accumulations of gas from the product of condensation."

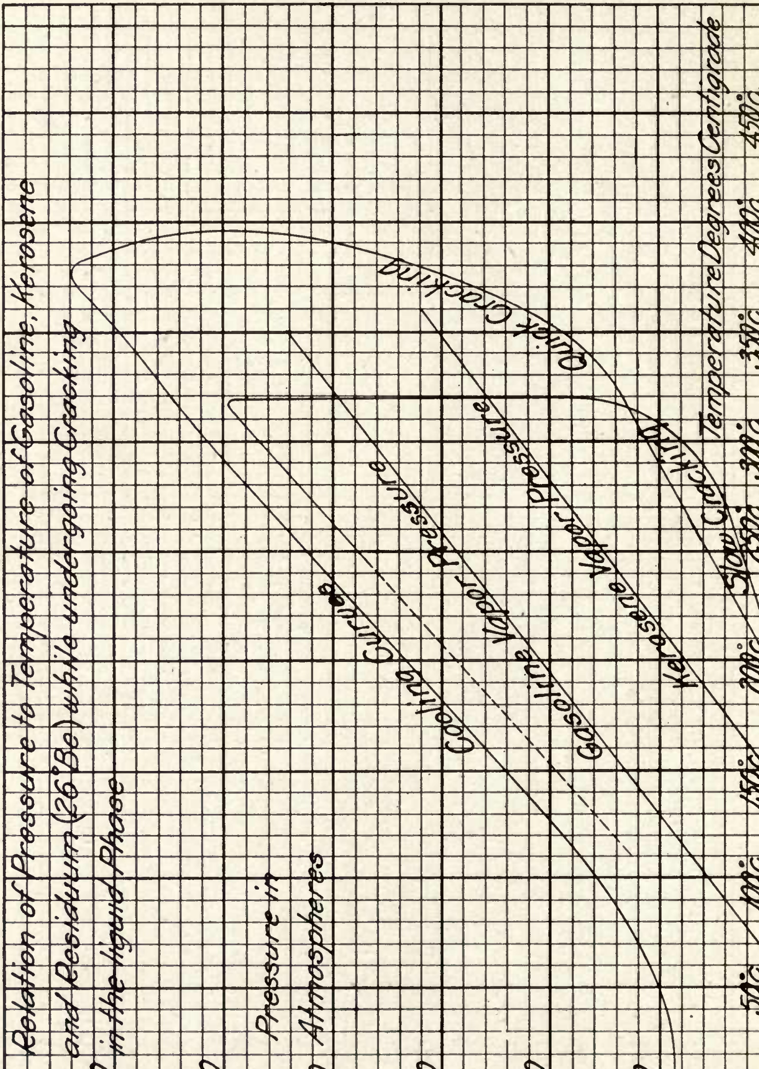
ADVANTAGES OF LIQUID PHASE CRACKING.

All processes of making gasoline which have not involved the treatment of the oil strictly in the liquid phase are said to have met with only a questionable degree of success.

While the cracking of oil in the vapor phase would be highly desirable if the product and other conditions were satisfactory, it has been claimed by many that the advantages of applying the heat to the liquid phase are as follows:

1. A lower temperature is sufficient to induce cracking.
2. The rate of reaction is greatly increased, being greater the higher the pressure within certain limits.
3. A product containing smaller amount of olefins and aromatics is produced.
4. A higher yield of refined gasoline is obtained.
5. There is a better economy of heat.
6. There is a selective action on the oil or heavy portions of the petroleum by reason of the automatic conversion of the desired product into the vapor phase, thus freeing it from further liability to decomposition.
7. There is a high oil capacity with small plant dimensions.
8. There is a perfect control of temperature.
9. There is a rapid and more complete absorption of heat from the furnace and less tendency to local overheating on account of the much higher specific heat of oil than of the oil vapor.
10. There is the possibility of operating either by intermittent charging or by continuous treatment and distillation.
11. The carbon is deposited in a suspended condition in the oil and not on the retaining walls.
12. There is the possibility of the use of the automatically developed pressure for mechanical and condensing purposes. The chief disadvantage in cracking oil in the vapor phase and under high pressure seems to be the danger attendant upon a possible failure of steel parts. (See page 112.)


RELATION OF SPECIFIC GRAVITY TO BOILING TEMPERATURE OF VARIOUS LIGHT HYDROCARBONS
FOUND IN OR PRODUCED FROM PETROLEUM
SPECIFIC GRAVITY
Boiling Temperature Degrees Fahrenheit
(Atmospheric Pressure)
1. Gasoline from cracking paraffin wax in the liquid phase
2. Garber Natural Gasoline
3 Towanda Natural Gasoline
4. Gasoline from cracked fuel oil in liquid phase
5 From cracked asphaltic oil in the liquid phase
Paraffins
Cn H2n+2 (Saturated)
Olefins CnH2n (open)
Pure paraffin Hydrocarbons
Naphthenes Cn H2n (Cyclic) from Russian Petroleum
Approx. from Redwood
Fuel oil cracked at 1200°F Vapor Phase
from Louisiana Petroleum
"Band A" tar drips from petroleum Gas Plant
AROMATICS Cn H2n-6 (Cyclic)
Coal tar naphtha
Xylol
Benzol
Turpentine
Toluol
Duodecane
Undecane
Decane
Nonane
Octane
Heptane
Hexane
400°F
350
300
250
200
150
100
50
600
700
750
800
850
900


Relation of Pressure to Temperature of Gasoline, Kerosene
and Residuum (26° Be) while undergoing Cracking
in the liquid Phase
Pressure in
Atmospheres
60
50
40
30
20
10
0
Temperature Degrees Centigrade
50°c.
100°c.
150°c.
200°c.
250°c.
300°c.
350°c.
400°c.
450°c.
Quick Cracking
Slow Cracking
Cooling Curve
Vapor Pressure
Gasoline Vapor pressure
Kerosene Vapor pressure

Standard Cracking Test for Heavy Petroleum Hydrocarbons

The apparatus is set up as shown in sketch (page 108). (a) is a cylindrical tube tested out to a pressure of 3,000 pounds such as is ordinarily used for dispensing oxygen gas. (b) is a thermometer well or plug with a tapered thread and of sufficient length that it protrudes well into the interior of the vessel (a). This plug has an opening from the outside into which the thermometer (c) is inserted. This thermometer is graduated preferably in degrees Centigrade and is of borosilicate glass, mercury and nitrogen filled and reading up to a temperature of 550°C. (d) is an extra heavy ammonia pipe fitting connected to a valve (e) and a pressure gauge (f). Pressure gauge (f) should read to at least 200 atmospheres or 200 kilograms per square centimeter. Heat is applied by gas burners (g) such as are used on combustion furnaces, and the whole apparatus is supported on a stand such as a combustion furnace with the end carrying the pressure gauge slightly elevated.

The capacity of the bomb is 1,500 to 1,600 cubic centimeters and 500 cubic centimeters of the oil to be tested are poured into it at a temperature of approximately 70°F. The plug (b) is inserted and screwed in very tightly using Stilson wrenches. The threads on the plug may be dressed with a mixture of equal parts of glycerin, litharge and copper oxide. The flame is applied so that it does not excessively heat the portion of the container not in contact with the oil. The total time consumed for the test after the beginning of the application of the heat should be between 55 minutes and 70 minutes. The heating is carried until a pressure of 55 atmospheres is attained based on a temperature of 400°C. It is desirable to keep the container covered with a sheet of asbestos during the operation. The temperature must at no time exceed 420°C. The apparatus is cooled to about 20°C before opening.

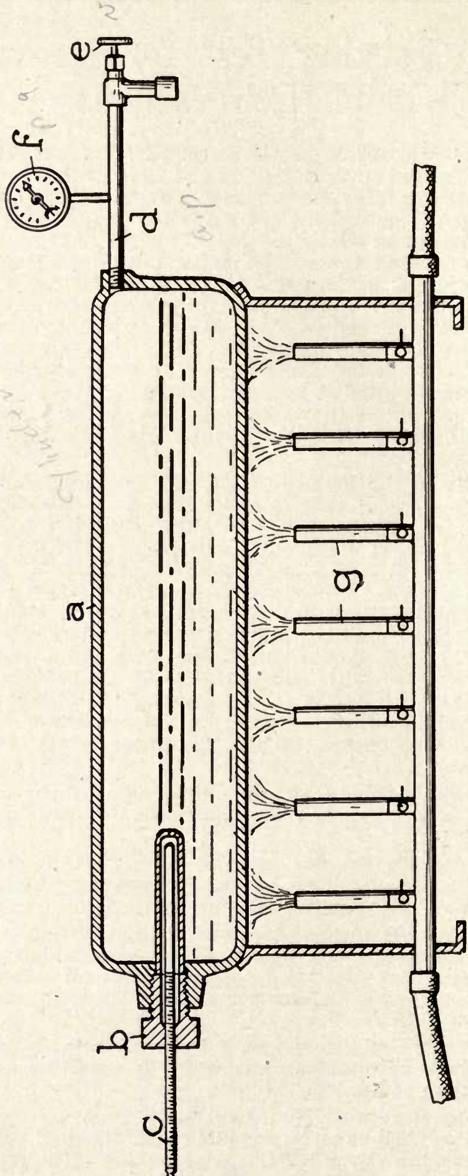
The constants in this test are the dimensions of the apparatus, the amount of oil used, the time of application of heat, and maximum pressure at 400°C.

The variables are the per cent by volume of oil recovered after cracking, the amount of carbon formed, the amount of gas formed, the specific gravity of the gasoline and the total yield of gasoline.

Variations are due to the character of the oil treated, the specific gravity of the gasoline being higher, the recovery higher, the carbon and gas formation less and the total amount of oil recovered greater with paraffin base and with low gravity oil than with naphthene base and high gravity oil.

From one such equilibrum test it is possible to approximately ascertain the amount of total gasoline which it would be possible to obtain from any type of oil.

This may be calculated from one equilibrium test by taking into consideration the shrinkage on cracking and the increase in specific gravity of the residue above 210°C after cracking. The following pages show cracking tests made with various oils and under varying conditions.


a
b
c
d
e
f
g

Equilibrium Cracking Tests on Different Heavy Petroleum Hydrocarbons

Oil Used.	No. 1	No. 2	No. 3	No. 4	No. 5
Specific Gravity	0.912	0.935	0.868	0.820	0.953
Baume Gravity	23.5	19.7	31.3	40.8	16.9
Amount cc	500	500	500	500	500
Viscosity at 70°F	810	3360	183	solid	5400
Max. pressure atm.	59	60	58	58	56
Max. temperature °C....	417	420	420	420	390
Pressure at 400°C atms..	54	55	56	54.5	55
Pressure after cooling (atms.)	10	10	9.5	6.0	11.5
Gas % by weight	7	7	6.8	4.5	8.0
Oil recovered—cc	465	460	495	493	440
Specific Gravity ...	0.862	0.862	0.824	0.775	0.917
Baume Gravity	32.4	32.4	39.9	50.6	22.6
Viscosity at 70°F ..	47	47	38	38	100
% Volume	93.0	92.0	99.0	98.6	88.0
% Shrinkage	7.0	8.0	1.0	1.4	12.0
Gasoline (E.P.410°F) cc.	127	139.5	147	180.7	135.5
% Volume	25.4	27.9	29.4	36.1	27.1
Specific Gravity....	0.743	0.746	0.745	0.724	0.753
Baume Gravity.. ..	58.4	57.6	57.9	63.3	55.9
Residuum % volume...	67.6	64.1	69.6	62.5	60.9
Specific Gravity....	0.926	0.926	0.886	0.820	0.962
Baume Gravity.. ..	21.2	21.2	28.0	40.8	15.5
Viscosity at 70°F. ..	135	178	70	104	414

No. 1=Mid-Continent fuel oil average of 48 cars on Kansas City market.

No. 2=Heavy Kansas crude oil from Allen County.

No. 3=Garber Residuum from Enid, Oklahoma.

No. 4=Paraffin wax.

No. 5=California crude oil.

Equilibrium Cracking Tests on Different Heavy Hydrocarbons

Oil Used	No. 6	No. 7	No. 8	No. 9	No. 10
Specific Gravity	0.946	0.889	0.820	0.886	0.994
Baume Gravity	18.0	27.5	40.8	31.6	10.8
Amount—cc	500	500	500	500	500
Viscosity at 70°F	1038	272	34	66	14500
Max. pressure atms....	58.5	59.5	59.5	61	50
Max. temperature °C..	412	415	420	414	410
Pressure at 400°C (atms.)	54.5	54.5	53.0	55.0	45.0
Pressure after cooling (atm.)	11.5	9.5	6.0	9.0	12.5
Gas % by weight	8.0	6.8	5.0	6.3	8.5
Oil recovered—cc	442	470	482	470	350
Specific Gravity....	0.887	0.861	0.803	0.842	0.898
Baume Gravity....	27.8	32.6	44.3	36.2	25.9
Viscosity at 70°F...	47	42	34	37	110
% Volume	88.4	94.0	96.4	94.0	70.0
% Shrinkage	11.6	6.0	3.6	6.0	30.0
Gasoline (E.P.410°F) cc	118	157	199	173	109
% Volume	23.6	31.4	39.8	34.6	21.8
Specific Gravity...	0.753	0.754	0.767	0.748	0.746
Baume Gravity..	57.6	57.1	52.5	55.6	55.9
Residuum % volume...	64.8	68.6	56.6	59.4	48.2
Specific Gravity...	0.944	0.911	0.845	0.925	0.982
Baume Gravity....	18.3	23.6	35.6	21.3	12.6
Viscosity at 70°F. .	218	88	38	86	530

No. 6=California heat treated and skimmed.
No. 7=Healdton crude.
No. 8=Mid-Continent kerosene.
No. 9=Mid-Continent gas oil.
No. 10=Mexican flux oil (natural).

Effect of Varying Pressure on the Products of Cracking

Kerosene.

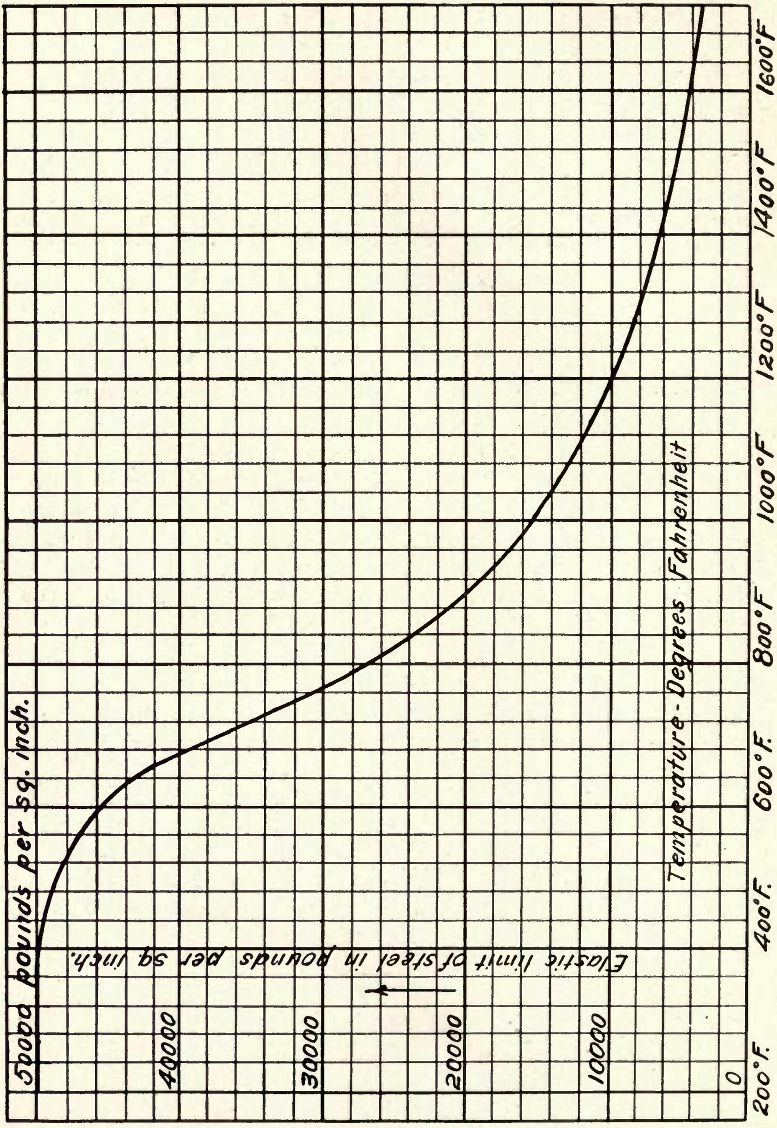
Using kerosene of specific gravity 0.8155 in vessel with relation of vapor space to oil of 2 to 1.

Pressure, atmospheres	30	40	55	75	90
% distillate to 410°F	28.0	32.5	38.0	43.7	45.9
Shrinkage, volume %	0.0	0.4	2.4	5.0	7.0
Specific gravity of cracked oil	.810	.808	.807	.806	.805
Specific gravity of residue	.828	.833	.845	.871	.888
Cold pressure, atmospheres	2.5	4.0	6.5	10.0	11.8

Fuel Oil.

Fuel oil with specific gravity of 0.908 in vessel with relation of vapor space to oil of 2 to 1.

Pressure, atmospheres	30	40	55	75	90
% distillate to 410°F	14.3	22.3	25.4	32.5	38.7
Shrinkage, volume %	3.0	3.3	9.0	12.0	14.0
Specific gravity of cracked oil	.879	.869	.862	.837	.818
Specific gravity of residue	.914	.918	.926	.930	.932
Cold pressure, atmospheres	5	6	10	13	15.5


50000 pounds per sq. inch.
40000
30000
20000
10000
0
Elastic limit of steel in pounds per sq. inch.
Temperature-Degrees Fahrenheit
200°F.
400°F.
600°F.
800°F
1000°F
1200°F
1400°F
1600°F

Medicinal Products of Petroleum

The official United States Pharmacopoeia products of petroleum are Petroleum Jelly, Liquid Paraffin, Solid Paraffin and Petroleum Benzine.

Petroleum Jelly (Petrolatum, petrolatum ointment, petrolatum album, white petroleum jelly) is a purified mixture of semi-solid petroleum hydrocarbons. It is an unctious mass varying in color from yellowish to white, having not more than a slight fluorescence and free from odor or taste. It is insoluble in water and freely soluble in ether, chloroform, carbon bisulphide, oil of turpentine, petroleum benzine, benzene and in most fixed or volatile oils. The specific gravity is .820 to .865 at 60°C. It melts between 38°C and 54°C. It sells on the market for from 5 cents per pound for the yellow to 12 cents per pound for the snow white.

Liquid Paraffin (liquid petrolatum, mineral oil) is a mixture of liquid hydrocarbons obtained from petroleum. It has a specific gravity of from .828 to .905 at 25°C. It is nearly free from fluorescence, odorless and tasteless and has a cold test of below 10°C. It is the only preparation of petroleum used internally. Its dose is four teaspoonsful. The colorless grade sells at from 50 cents to 75 cents per pound. White mineral oil is put on the market under various trade names such as Nujol, Stanolind, Bakurol, Med-O-Lin, Interol, Muthol and Whiteruss.

Paraffin or Paraffin Wax is a purified mixture of solid petroleum hydrocarbons. It is colorless and has a specific gravity in the solid form of about .900 at 25°C. It melts at from 50°C to 57°C. It is worth from 8 cents to 17 cents per pound, dependent upon the melting point.

Petroleum Benzine is practically very light gasoline perfectly refined, boiling at about 104°F and with an end point of about 180°F. It has a gravity of 82°Be′ to 89° Be′.

The first medicinal use of petroleum was in the form of the crude and sold extensively in this country as Seneca Oil.

Ichthyol is an artificial preparation obtained by the distillation of certain bituminous shales and subsequent sulphonation and neutralization with ammonia or soda. It comes on the market under the official name of Ammonii Icythyo-sulphonas or Ammonium Sulpho-ichthyolate. The specific gravity of the preparation is approximately 1.0 and it has a viscosity of 17.7 (Engler). A typical preparation contains 15% to 16% of sulphur and it is to the sulphur that the value of the preparation is largely due. On account of the difficulty in duplicating exactly the original product and the scarcity of the original product, it has now attained a very high price.

Common Tests of Petroleum Products with Minimum Sample Required for Tests

A. Crude Oil.

		Minimum sample.
1.	Specific gravity of crude oil	2 oz.
2.	Water and B. S. in crude oil	3 oz.
3.	Per cent gasoline with gravity and initial B. P. kerosene with gravity and fuel oil with gravity	1 pt.
4.	Refiner's fractional distillation showing per cent distilled, total gravity, end gravity, and end boiling point on each fraction	1 gal.
5.	Asphalt in crude oil, fuel oil or road oil	3 oz.
6.	Calorific value in B. T. U. per pound and per gallon and per cent sulphur in gasoline, kerosene, distillate, fuel oil, crude oil or asphalt (by Emerson Bomb Calorimeter)	1 oz.
7.	British Thermal Units alone in any product of petroleum	1 oz.
8.	Sulphur in any product	1 oz.
9.	Paraffin in crude oil, fuel oil, road oil or asphalt	3 oz.
10.	Lubricating stock in crude oil or fuel oil	6 oz.
11.	Nitrogen in crude oil, fuel oil, road oil or asphalt	1 oz.
12.	Viscosity, any temperature or instrument	3 oz.
13.	All of above tests	2 gal.
14.	Cracking test for amount of total gasoline obtainable from kerosene, gas oil, fuel oil or crude oil	1 gal.

B. Fuel Oil (See also Crude Oil)

1.	Gravity, B. S., water, flash, fire, B. T. U., per pound and per gallon	4 oz.
2.	Viscosity	4 oz.
3.	Sulphur	1 oz.
4.	Gravity and heating value	4 oz.
5.	Examination of Diesel engine oil	8 oz.

C. Gasoline, Naphtha, Kerosene and Distillate.

1.	Gravity and distillation test, 5% fractions with B. P. and end point	4 oz.
2.	Specific gravity, U. S. Sandard Baume' gravity and Petroleum Association gravity	4 oz.
3.	Distillation test, boiling point, flash, fire, carbon residue, gravity and color of gas oil or distillate and per cent olefins	8 oz.

D. Road Oils (See Crude Oil and Asphalt)

		Minimum sample.
1.	Specific gravity and Baume'............................	4 oz.
2.	Viscosity, any instrument or temperature..............	8 oz.
3.	Flash and fire tests....................................	8 oz.
4.	Loss at 325°F 5 hours................................	4 oz.
5.	Per cent asphalt of 100° penetration..................	4 oz.
6.	Fixed carbon	1 oz.
7.	Solubility in carbon bisulphide, carbon tetrachloride, petroleum ether or benzol................................	1 oz.

E. Asphalt.

1.	Determination of bitumen and grading in surface mixture	½ lb.
2.	Examination of asphaltic cement from kettle for penetration, ductility and cementition.........................	3 oz.
3.	Complete chemical and physical examination of asphaltic cement covering all points required by any specification	5 lbs.
4.	Complete examination of asphalitc cement covering the usual specifications....................................	1 lb.
5.	Determination of specific gravity, ductility, melting point, flash point, fire test, penetration, fixed carbon, viscosity, solubility, volatility and sulphur, each..................	1 lb.
6.	Short analysis of oil residuum for suitability for road purposes giving percentage of asphalt..................	1 lb.
7.	Paraffin scale in asphaltic cement......................	1 oz.
8.	Complete examination of asphalt rock.................	5 lbs.

F. Lubricating Oils.

1.	Specific gravity, color, odor, flash, fire, sediment, cold test, pour test or acid...............................	4 oz.
2.	Viscosity	4 oz.
3.	Solubility in CS_2 CCl_4 or petroleum ether..............	1 oz.
4.	Carbon residue	1 oz.
5.	Sulphur	1 oz.
6.	All of above tests....................................	8 oz.

G. Paraffin Wax.

1.	Melting point, color, odor, oil, volatility................	1 oz.

Information Concerning Oil Shales

The chief occurrences of oil shale in the United States are in Western Colorado,—Northeastern Utah,—Kentucky,—Elko, Nevada,—Great Falls, Montana,—Parkfield, California,—New Brunswick, Canada,—Alabama,—Tennessee and Virginia. It is estimated that in Colorado there are enough oil shales to produce 20,000 million barrels of oil and 300 million tons of ammonium sulphate.

The shale oil industry started in England in 1694. The oil was used for medicinal purposes, later for varnishes and in 1815 for ammonia.

The chief commercial operations on oil shale are in Scotland and were begun in 1847. These industries were demoralized when Pennsylvania petroleum first appeared on the market, but later recovered partially and are now operated with profit. The amount of oil obtainable from one ton of shale varies from one gallon to 90 gallons. In Scotland it is 23 gallons. In Colorado alone there is said to be enough shale to produce 20,000,000,000 barrels of oil and 300,000,000 tons of ammonium sulphate.

Gasoline made from shale is of inferior quality, containing large amounts of olefins and aromatic compounds and giving a large shrinkage on refining.

Shale oil is especially adapted to the uses to which the heavy products of petroleum are now put, such as fuel oil, paraffin wax, lubricants, gas oil and illuminating oil. It is not likely to be so satisfactory for the production of gasoline as is the cracking of heavy petroleums. The character of the oil recovered and the amount of ammonium sulphate produced from shale depend largely upon the method of distillation.

Oil shale rock is a tough brownish to black shale-like rock. As it naturally exists it contains no oil and oil cannot be extracted from it by solvents or by any of the means used for asphaltic sandstone or limestone. The oil is produced from complex organic matter by decomposing it at high temperatures.

The mineral base of oil shales is of the nature of kaolin and contains potash in water insoluble form.

Cannel coal is of the same chemical nature as oil shale both as to the bitumen and the mineral matter. The hydrocarbons of oil shale and cannel coal more nearly approach petroleum than coal in their calorific value.

Unlike coal, cannel "coal" has no structure or evidence of the former presence or origin from vegetable matter. It breaks with a conchoidal fracture and is usually free from mineral sulphides such as pyrites of iron. It commonly occurs on the top of the Mississippian (subcarboniferous) and may lie immediately above deposits of galena or sphalerite (zinc).

Presumptive Operation of 1000-Ton Shale Oil Plant in Western Colorado

(Based upon 1 ton of shale.)

	1918	1913
Proceeds.		
54 gallons of oil (405 lbs.)	$ 2.70	$ 1.00
34 pounds of ammonium sulphate	2.46	1.09
	$ 5.16	$ 2.09
Costs.		
*Cost of mining	$ 1.35	$ 0.90
Cost of distilling oil and ammonia	.65	.50
Cost of acid for ammonia	.55	.16
*Freight on acid to plant	.12	.12
Cost of preparation of ammonium sulphate for market	.10	.06
*Freight on ammonium sulphate to market	.17	.17
*Freight on oil	1.00	1.00
Overhead expense	.40	.25
	$ 4.34	$ 3.16

*Depends upon local conditions to a large extent.

PROFITS IN SHALE INDUSTRY BY COMPANIES IN SCOTLAND IN 1910.

Companies.	Dividends.
Broxburn	17.5%
Oakland	15.0
Pumpherston	50.0
Tarbrax	15.0
Youngs	6.0
Dalmeny	5.0

CANNEL COAL FROM CENTRAL MISSOURI.

(Large quantities of this hydrocarbon are found in Missouri.)

	Sample a	Sample b
Moisture	8.14%	2.56%
Volatile hydrocarbons	41.16	44.78
Fixed carbon	36.63	42.72
Ash	14.07	9.94
	100.00	100.00
Fusing of bitumen	none	none
Total combustible	77.79	87.50
Heating value in B. T. U., per lb	12575	14095
B. T. U., per lb. of combustible	16165	16110
Sulphur	2.10%	1.70%
Nitrogen	1.50	1.65
Oil, per ton from retorts	64 gallons	72 gallons
Ammonium sulphate, per ton	50 pounds	55 pounds
Coke, per ton	1080 pounds	1200 pounds

COMPOSITION OF ASH IN CANNEL COAL.

Silica	(SiO_2)	=43.28%	
Iron and	(Fe_2O_3)	=12.00	46.16
Alumina	(Al_2O_3)	=34.16	
Lime	(CaO)	= 1.49	
Magnesia	(MgO)	= 1.01	
Sulphur	(SO_3)	= 0.84	
Phosphorus	(P_2O_5)	= 0.73	
Potash	(K_2O)	= 3.00	

SHALE OIL PRODUCTS.

Yields from "Oil Shale" from Colorado.

(100,000 million tons of shale of this quality are said to be available.)

Oil	= 405 lbs.	=54 gallons	=20.25%
Water	= 83 lbs.	=10 gallons	= 4.08%
Gas	=1605 cu. ft.		= 8.86%
Ammonium Sulphate=34 lbs from nitrogen			= 0.90%
Carbon (not separable)=101 lbs.			= 5.05%
Mineral matter=1219.2 lbs.			=60.96%

COMPOSITION OF MINERAL ASH IN SHALE.

Loss on ignition		= 11.05%
Silica	(SiO_2)	= 37.10%
Alumina	(Al_2O_3)	= 20.30%
Iron Oxide	(Fe_2O_3)	= 9.20%
Lime	(CaO)	= 12.05%
Magnesia	(MgO)	= 5.10%
Sulphur	(SO_3)	= 4.80%
Alkalies and difference		= 0.40%
		100.00%

PROPERTIES OF SHALE OIL.

Commercial Fractions.

Naphtha (410°F) "gasoline"	10.0%	(46° Baume')
Burning oil	18.2%	
Gas and lubricating oil	61.8%	
Scale	10.0%	

Fractional Distillation of oil.

Fraction	Boiling Point	Specific Gravity (25°C)
0— 10	100°C	0.794=46.3°Be'
10— 20	194	0.822=40.3
20— 30	230	0.846=35.5
30— 40	255	0.867=31.5
40— 50	285	0.885=28.2
50— 60	309	0.899=25.7
60— 70	328	0.912=23.5
70— 80	337	0.900=25.5
80— 90	345	0.910=23.8
90—100	350	0.910=23.8

PRODUCTION OF OIL SHALE PRODUCTS IN SCOTLAND.

	1871	1879	1887	1893	1916
Crude oil, gal. per ton.	31.25	34.12	28.28	24.98	23.57
Crude oil, bbls. (U. S.).	593,310	690,500	1,258,000	1,160,000	1,965,000
Sulphate of Ammonia (tons)	2,350	4,750	18,483	28,000	59,400
Number of companies operating	51	18	13	13	6

Natural Gas

Natural gas is found trapped in the various strata of the earth, principally in sandstone formations of loose texture, in shale seams and in cavities. It is usually associated with petroleum or coal and occurs in the carboniferous strata or in more recent formations. In coal mines it constitutes what is known as fire damp, being given off from the exposed seams of coal. It is most commonly associated with petroleum in petroleum bearing sand and occupies the space in the sand above the oil. Occasionally it occurs in strata without any oil being present, in which case it is of a slightly different composition than the gas which is found in contact with the oil. In many cases it appears that the gas has been obtained from the atmosphere, the oxygen having been removed by its combination with reducible substances such as sulphides, leaving a residue of nitrogen. This gives to such natural gases the peculiarity of having a very large amount of nitrogen. Associated with the nitrogen there occasionally is found a small amount of Helium which is also an ordinary constituent of air in small quantities. It may be that the difference of solubility of the different gases of the air in water may account for the tendency of accumulation of Helium in such instances. As a rule, however, natural gas consists of hydrocarbons of the same type as petroleum and identical with the hydrocarbons which are given off by the cracking of petroleum.

The proportions in which the different hydrocarbons exist in ordinary gas such as is delivered to Kansas City, Missouri, is something like the following:

Methane	84.7%
Ethane	9.4%
Propane	3.0%
Butane	1.3%
Nitrogen	1.6%

This gas has the greater portion of the heavy hydrocarbons condensed out on account of the high pressure in the pipe lines. Such a gas is a mixture of methane with a varying amount of the other gases. As shown by the above table, the gases ethane, propane and butane furnish much of the heating value of the gas. A gas with a considerable amount of gasoline vapor in it will have a considerably higher heating value than one from which it has been removed, or known as a dry gas.

The compositions of the natural gas used in eight cities in the United States are as follows:

City.	Methane Per cent	Ethane Per cent	Nitrogen Per cent
Pittsburgh, Pa.	79.2	19.6	1.2
Louisville, Ky.	77.8	20.4	1 8
Buffalo, N. Y.	79.9	15.2	4.9
Cincinnati, O.	79.8	19.5	.7
Cleveland, O.	80.5	18.2	1.3
Springfield, O.	80.3	14.7	5.0
Columbus, O.	80.4	18.1	1.5
Chelsea, Okla.	75.4	17.7	6.6

These analyses were made by the ordinary combustion method and hence show only the two predominating paraffin hydrocarbons.

The composition of gases found in Kansas and Oklahoma as given by Allen and Lyder are shown by the following table:

Location.	Methane	Ethane	Nitrogen	B.T.U. per cubic foot
Augusta, Kas.	10.54	1.64	87.69	129
Cowley County, Kas.	16.27	3.01	80.23	209
Chautauqua County, Kas.	42.38	1.85	55.29	441
Chautauqua County, Kas.	49.01	3.89	46.67	541
Ellsworth, Kas.	61.09	1.09	37.20	609
Ponca City, Okla.	44.60	14.86	40.10	688
Kay County, Okla.	57.91	9.89	31.65	735
Chautauqua County, Kas.	85.53	0.15	12.95	839
Chautauqua County, Kas.	79.13	7.79	11.39	894
Butler County, Kas.	62.15	18.38	18.64	930
Montgomery County, Kas.	83.04	8.54	7.95	970
Blackwell, Okla.	70.69	18.65	9.32	1025
Cushing, Okla.	70.74	21.64	7.49	1059
Bartlesville, Okla.	70.50	24.60	3.21	1125

The presence of such a large amount of nitrogen in some cases makes the gas almost valueless unless some process is used whereby the nitrogen may be adapted to chemical processes.

While natural gas has a very high heating value in comparison with water gas, water gas has the advantage in that it gives a more intense flame. The comparison of various commercial gases is shown in the following table:

PROPERTIES OF NATURAL AND MANUFACTURED GASES.

Constituents	Avg. Pa. & W. Va.	Avg. Ohio & Ind.	Avg. Kansas	Avg. coal gas	Avg. water gas	Avg. producer gas from bituminous coal
Marsh gas, CH_4	80.85	83.60	93.65	40.00	2.00	2.05
Other hydrocarbons	14.00	.30	.25	4.00	.00	.04
Nitrogen	4.60	3.60	4.80	2.05	2.00	56.26
Carbonic acid CO_2	0.00	.20	.30	.45	4.00	2.60
Carbonic Oxide CO	.40	.50	1.00	6.00	45.50	27.00
Hydrogen	.10	1.50	.00	46.00	45.00	12.00
Hydrogen Sulphide	.00	.15	.00	.00	.00	.00
Oxygen	trace	.15	.00	1.50	1.50	.05
Total	100.00	100.00	100.00	100.00	100.00	100.00
Pounds in 1000 cu. ft.	47.50	48.50	49.00	33.00	45.60	75.00
Sp. grav. air being 1.00	0.624	0.637	0.645	0.435	0.600	0.935
B.T.U. per cu. ft.	1,145	1,095	1,100	755	350	155

(a) 1000 cu. ft. of air at an atmospheric pressure of 14.7 pounds and at a temperature of 62°F weighs 76.1 lbs. and is a mechanical mixture of 23 parts of oxygen and 77 parts of nitrogen by weight.

(b) B.T.U. equals British thermal units which indicate the heat necessary to raise one pound of pure water at 39°F one degree.

Natural gas may have its origin from a sand which is entirely separated from sand containing oil or it may come from above the oil in the same sand as oil.

In the latter case, the lighter portions of the oil will have been volatilized and carried into the gas. Such a gas is known as a "wet" gas. In other words, the wet gas is composed of the usual constituents of dry gas, that is, methane, ethane, propane and butane, and in addition, pentane, hexane and heptane. These last three are liquid at ordinary temperatures and are the most desirable components of gasoline.

Gas coming from a sand containing no oil is "dry" gas and does not contain the pentane, hexane and heptane.

A "wet" gas coming from an unknown sand indicates the presence of oil in that sand.

In the ordinary oil well the gas is allowed to escape between the casing of the well and the tube which has been inserted for withdrawal of the oil. The gas so collecting in the casing is known as casinghead gas and may be used or allowed to escape.

This gas collecting in the casinghead of an oil well is "wet" gas and contains some of the gasoline from the oil. The gasoline which may be compressed from it or refrigerated from it is then known as "casinghead" gasoline.

The lighter the oil with which the casinghead gas has been associated, the greater ordinarily will be the amount of gasoline contained in the gas.

Ever since natural gas has been conducted in pipe lines it has been known that gasoline could be separated by pressure and much has been incidentally so produced. More recently the great demand for gasoline has encouraged the design of hundreds of special plants for the extraction of gasoline from natural gas.

In 1904 at Titusville, Pennsylvania, Fasenmeyer made casinghead gasoline by pumping the gas under pressure through a coil under water.

In the early methods, pressures of about fifty pounds per square inch were used. Later, condensing with a pressure of 400 pounds per square inch was found to produce too "wild" a gasoline or one that escaped too easily on handling. A pressure of 250 pounds per square inch is now used and the pressure of the condensed liquid is controlled by absorbing it directly into heavier naphtha.

At first the compression was done in one stage but it is the custom now to do it in two stages. The gravity of the product is from 80 to 100° Baume'.

The amount of casinghead gasoline present in a gas will depend upon the character of the oil associated with it, the temperature, the pressure, the compactness of the sand and the condition in the sand at the point tapped.

The amount of gasoline obtained from casinghead gas in the Mid Continent field varies from ½ to 8 gallons per 1000 cubic feet. A typical gas yields 2½ gallons per 1000 cubic feet. Many yield 3 to 4 gallons per 1000 cubic feet.

The total production of casinghead gasoline in the United States in 1916 was as follows:

Gasoline extracted from Natural Gas and Sold in 1916

State	Number of plants	Quantity (gallons)	Value	Average recovery of gasoline per 1000 cu. ft.
Oklahoma	116	49,079,722	$5,942,198	1.968
West Virginia	147	18,765,056	3,025,293	.179
California	26	17,158,754	2,293,822	.691
Pennsylvania	195	9,714,926	1,726,173	.252
Ohio	53	2,638,571	470,804	.485
Illinois	32	2,260,288	262,664	1.688
Louisiana	7	2,113,159	269,564	2.329
Texas	4	1,292,811	201,023	1.363
Kentucky	5	725,467	141,347	.129
Kansas	3	215,000	35,030	.132
New York } Colorado }	6	249,055	40,283	2.422
Total	594	104,212,809	14,408,201	.499

The cost of plants for producing casinghead gasoline has varied from \$12 to \$25 per thousand cubic feet of gas handled and the operation of the plants has been uniformly successful and highly profitable.

While the type of plant ordinarily constructed is for compression methods it is probable that the absorption method will be more generally adopted. The operation of the absorption method is similar to that of extracting toluol from coal gas and may be applied to a natural gas capable of yielding one pint of gasoline per 1000 cu. ft. By the use of the absorption process 50 million cu. ft. of natural gas would be available per day and 100 million gallons of light gasoline would be made.

Yield of Gasoline from Casinghead Natural Gas by Compression Method, Corresponding to Absorption and Specific-Gravity Tests.

Absorption by oil, per cent.	Specific gravity. (Air=1.)	Yield of gasoline, gallons per 1,000 cubic feet of gas.	Absorption by oil, per cent.	Specific gravity. (Air=1.)	Yield of gasoline, gallons per 1,000 cubic feet of gas.
16	0.64	None	50	1.29	3.00
23	.83	1.00	48	1.37	3.50
30	.90	1.75	44	1.38	3.50
37	1.00	2.00	65	1.38	4.00
39	1.03	2.50	84	1.41	4.50
38	1.07	3.00	86	1.46	5.00
54	1.21	3.50			

Determination of Specific Gravity of Gas

The apparatus consists of a glass jar, b, with a metal top into which fits a brass column having suspended from its base a long, graduated tube, a, and at its top a cock, c, and a ground-joint socket, d, into which sets a socket holding a small glass tip, e, closed at the top with a thin piece of platinum, f. In this platinum is a minute hole to permit the passage of gas or air at a very slow rate. All the metal parts are nickeled. The mode of operation is as follows: The glass jar is filled with water to the top graduation mark of the tube or to a point a little above it. The tube is then withdrawn so that it may be filled with air. The cock on the standard is then closed and the tube is replaced with air. The cock is then opened, and the number of seconds required for the water to pass from the lowest graduation mark to the graduation mark above it is recorded with a stop watch. The tube is then withdrawn and filled with gas and the procedure repeated. The specific gravity (air=1) is obtained by dividing the gas time squared by the air time squared. Thus, if A represents the time required for the gas to pass through the orifice, and B represents the time required for the air to pass through the orifice, the specific gravity of the gas will be represented by

$$\left\{\frac{A}{B}\right\}^2$$

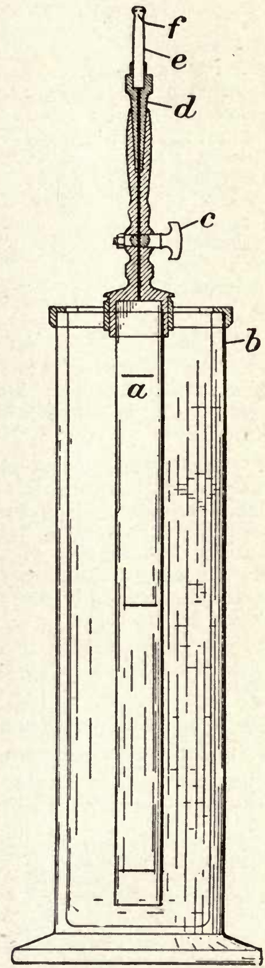


Figure 1.—Apparatus for determining specific gravity of natural gas.

PROPERTIES OF HYDROCARBONS FOUND IN NATURAL GAS.

	Methane	Ethane	Propane	Butane	Pentane	Hexane	Heptane	Octane
Formula	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}	C_6H_{14}	C_7H_{16}	C_8H_{18}
Molecular weight	16.03	30.05	44.07	58.08	72.10	86.12	100.13	114.15
Specific gravity	....	0.432=	0.515=	0.585=	0.630=	0.670=	0.697=	0.718=
Liquid	....	194°Be'	142°Be'	109°	92.2°	78.9°Be'	70.9°Be'	65.0°Be'
Gaseous	0.555	1.049	1.526	2.008	2.496	2.982	3.467	3.952
Boiling point	−165°C −265°F	−93°C −135°F	−45°C −49°F	+1 34°F	36.3°C 97°F	69.0°C 156°F	98.4°C 200°F	125.5°C 258°F
Vapor pressure @ 70°F, % of atmosphere	100+	100+	100+	100+	55%	10%	2.7%	.7%
Lbs. per 1000 cu ft. @ B.P. (red to 60°F)	42.	79.7	116.	152.6	189.7	226.6	263.5	300.0
Gallons per 1000 cu. ft. @ B.P. (red to 60°F)	....	4.13	7.17	10.72	14.35	18.22	22.05	25.86
Volume shrinkage by 1 gal liquid removed per 1000 cu. ft.	....	....	....	....	7.0%	5.5%	4.5%	3.9%
Max. gallons per 1000 cu. ft. @ 70°F	0	0	0	0	7.8%	1.8%	0.6%	0.18%
Heating value B.T.U.								
Per cu. ft.	1065	1861	2685	3447	4250	5012	5780	6542
Per lb.	25350	23350	23150	22590	22400	22120	21935	21807
Air to burn 1 ft. of gas pounds	9.57	16.72	23.92	31.10	38.28	46.46	53.6	60.8

NATURAL GAS PRODUCED IN THE UNITED STATES IN 1916.

State	Quantity M.cu.ft.	Price, cents per M.cu.ft.	Value
West Virginia	299,318,907	15.90	47,603,396
Pennsylvania	129,925,150	18.74	24,344,324
Oklahoma	123,517,358	9.70	11,983,774
Ohio	69,888,070	22.32	15,601,144
Louisiana	32,080,975	8.29	2,660,445
Kansas	31,710,438	15.31	4,855,389
California	31,643,266	17.19	5,440,277
Texas	15,809,579	18.89	3,143,871
New York	8,594,187	29.37	2,524,115
Illinois	3,533,701	11.22	396,357
Arkansas	2,387,935	10.13	241,896
Kentucky	2,106,542	35.73	752,635
Indiana	1,715,499	29.34	503,373
Wyoming and Colorado	575,044	14.97	86,077
Montana	213,315	18.21	38,855
Dakotas and Alabama	77,478	40.75	31,573
Missouri	69,236	25.41	17,594
Tennessee	2,000	57.50	1,150
Michigan	1,298	73.04	948
Iowa	275	100.00	275
Totals	753,170,253	15.96	120,227,468

GASOLINE AND NATURAL GAS EXPLOSIONS.

An explosion or a detonation is a chemical reaction which goes on with increasing velocity and is accompanied by a rise of temperature. The lowest temperature at which combustion or explosion of a mixture may take place is called the ignition temperature. This varies greatly with different kinds of gases, being with ordinary hydrocarbon gases, such as natural gas, about 650°C. The vapors of some substances such as carbon bisulphide and hydrogen sulphide are capable of ignition at much lower temperatures, even as low as 100°C. Some gases even inflame spontaneously at room temperature. These are phosphorus dihydride, boron and silicon hydride and cacodyl. Ordinarily, explosive mixtures are ignited by the presence of a flame or spark at any point in the mixture ordinarily greater than .2 of a millimeter in length. In order that the gaseous mixture explodes it is necessary that the heat generated by the local combustion be greater than the heat absorbed by the surrounding gases. This means of course that if the mixture is heated to a high temperature it will be more readily explosive though the pressure will exert very little influence. An excess of either the combustible agent or the oxidizing agent in the mixture will have the same cooling effect that is exerted by any inert gas. The result is that the limits of explosibility of various mixtures of combustible gases and air are dependent upon the heat generated by the combination and by the heat absorbed in raising the temperature of the gases. For ordinary gases the following limits hold as to the range of combustion with combustible mixtures when air is the oxidizing agent:

LIMITS OF EXPLOSIBILITY OF MIXTURES OF COMBUSTIBLE GASES AND AIR.

Gasoline vapor	1.5— 6.0%	by volume of mixture
Methane	5.5—14.5	by volume of mixture
Ethane	2.5— 5.0	by volume of mixture
Natural gas	5.0—12.0	by volume of mixture
Acetylene	3.0—73.0	by volume of mixture
Artificial Illuminating gas	7.0—21.0%	by volume of mixture
Hydrogen	5.0—72.0	by volume of mixture
Carbon Monoxide	15.0—73.0	by volume of mixture
Blast furnace gas	36.0—65.0	by volume of mixture
Water gas	9.0—55.0	by volume of mixture
Coal gas	6.0—29.0	by volume of mixture
Ethene	4.0—22.0	by volume of mixture

The striking back of a flame in a burner is caused by the presence of an explosive mixture in the burner. While the usual rate of striking back of the flame or the propagation of an explosion is over 6000 feet per second and about seven times the rate of sound in the same medium; this rate exists only when there is no retardation of the explosive wave caused by the cooling effect of the orifice or tube through which it passes.

ABOUT NATURAL GAS AND ITS USEFULNESS.

An average sample of Natural Gas has 950 B.T.U. per cu. ft.
1 Lb. mill coal will evaporate 9 lbs. water.
1 Gal. oil will evaporate 100 lbs. water.
1 Cu. ft. gas will evaporate 0.85 water.
1 Ton coal used under boilers=18,500 cubic feet of gas.
1 Bbl. oil (42 gal.) under boilers=5,000 cubic feet of gas.
40 to 50 Cu. ft. of gas=1 boiler H.P.

Gas Engines:
Highest grade gas engines develop a brake H.P. on 8,500 B.T.U.
Average engine develops a H.P. on 10,500 B.T.U.
Oil-well engine develops a H.P. on 20,000 B.T.U.

In a steam turbine plant of over 500 K.W. capacity 30 cubic feet gas per K.W. is a fair average.

It requires 40,000 cubic feet of gas to pump one million gallons of water against two hundred-foot head.

Brick Plants—Gas used per thousand brick made:
1,800 cubic feet for power.
1,800 cubic feet for drying.
15.000 cubic feet for kilns.

Ice Plants: 2,000 feet gas per ton of refrigeration.

Zinc Plants:
15,000 cubic feet for roasting, per ton of metal produced.
65,000 cubic feet for smelting, per ton of metal produced.
20,000 cubic feet for power and miscellaneous uses, per ton of metal produced.

Cement Plants:
60 to 100 cubic feet per barrel for power.
80 to 100 cubic feet per barrel for roasters.
1,800 to 2,600 cubic feet per barrel for kilns.

Salt Plants:
Direct-fire pans, 9.000 cubic feet per ton.
Stream pans, 10,000 cubic feet per ton.
Single-effect vacuum pan, 15,000 cubic feet per ton.
Double-effect vacuum pan, 10,000 cubic feet per ton.
Triple-effect vacuum pan, 6,000 cubic feet per ton.

Flour Mills: 200 to 400 cubic feet per barrel.

GAS COMPRESSORS: Horse power required to compress 1000 cu. ft. of gas per minute.

To 15 lbs.	50 H.P.	
To 30 lbs.	85 H.P.	
To 45 lbs.	111 H.P.	
To 60 lbs.	134 H.P.	
To 80 lbs.	117 H.P.	(2 stages)
To 100 lbs.	151 H.P.	(2 stages)
To 200 lbs.	212 H.P.	(2 stages)

Horse-power required to compress 1000 cu. ft. of gas per hr. (Single stage)

To 15 lbs.	1 H.P.
To 30 lbs.	1.75 H.P.
To 45 lbs.	2.25 H.P.
To 60 lbs.	2.75 H.P.

Orifice Capacity

Diameter Inches		Area	Morse Drill Gage Size	Cubic Feet Per Hour		
Frac.	Decimal	Square Inch		Coal Gas 0.43 sp. gr. 2″ Press.	Water Gas 0.62 sp. gr. 2″ Press.	Natural Gas 0.62 sp. gr. 4½ Oz. Press.
	0.0135	0.000143	80	1.04	0.86	1.67
	0.0145	0.000165	79	1.16	0.97	1.89
1/64	0.0156	0.00019	—	1.26	1.05	2.05
	0.016	0.00020	78	1.32	1.10	2.14
	0.018	0.00025	77	1.35	1.13	2.20
	0.020	0.00031	76	1.62	1.35	2.63
	0.021	0.00035	75	1.80	1.52	2.96
	0.0225	0.00040	74	2.16	1.80	3.51
	0.024	0.00045	73	2.29	1.90	3.70
	0.025	0.00049	72	2.46	2.05	4.00
	0.026	0.00053	71	2.70	2.25	4.38
	0.208	0.00062	70	2.79	2.33	4.54
	0.0292	0.00067	69	3.08	2.57	4.97
	0.031	0.00075	68	3.23	2.70	5.26
1/32	0.312	0.00076		3.26	2.73	5.32
	0.032	0.00080	67	3.42	2.85	5.56
	0.033	0.00086	66	3.53	2.94	5.73
	0.035	0.00096	65	3.69	3.08	6.00
	0.036	0.00102	64	3.86	3.23	6.30
	0.037	0.00108	63	4.05	3.38	6.60
	0.038	0.00113	62	4.11	3.51	6.84
	0.039	0.00119	61	4.50	3.75	7.31
	0.040	0.00126	60	4.95	4.12	8.04
	0.041	0.00132	59	5.22	4.35	8.48
	0.042	0.00138	58	5.40	4.50	8.77
	0.043	0.00145	57	5.67	4.71	9.2
	0.0465	0.00170	56	6.57	5.47	10.6
3/64	0.0469	0.00173		6.75	5.63	11.0
	0.0520	0.0021	55	8.9	6.75	13.2
	0.0550	0.0023	54	9.0	7.50	14.6
	0.0595	0.0028	53	10.8	9.0	17.5
1/16	0.0625	0.0031		11.7	9.7	19.0
	0.0635	0.0032	52	11.9	9.9	19.3
	0.0670	0.0035	51	12.6	10.5	20.5
	0.070	0.0038	50	13.5	11.2	21.8
	0.0730	0.0042	49	14.4	12.0	23.4
	0.076	0.0043	48	15.3	12.7	24.8
5/64	0.0781	0.0048		15.7	13.1	25.5
	0.0785	0.0018	47	15.8	13.2	25.7
	0.081	0.0051	46	16	13.5	26
	0.082	0.0053	45	17	14.3	28
	0.086	0.0058	44	18	15	29
	0.089	0.0062	43	19	16.5	32
	0.0935	0.0069	42	20	17	33
3/32	0.0937	0.0069		21	18	35
	0.096	0.0072	41	22	19	37
	0.098	0 0075	40	23	20	39
	0.0995	0.0078	39	24	20.5	40
	0.1015	0.0081	38	25	21	41
	0.104	0.0085	37	26	22	43
	0.1065	0.0090	36	27	22.5	44
7/64	0.1093	0.0094		28	23	45
	0.110	0.0095	35	29	24	47
	0.111	0.0097	34	30	25	49
	0.113	0.0100	33	31	26	51
	0.116	0.0106	32	32	27	53

ORIFICE CAPACITY—Continued.

Diameter Inches		Area	Morse Drill Gage Size	Cubic Feet Per Hour		
Frac.	Decimal	Square Inch		Coal Gas 0.43 sp. gr. 2" Press.	Water Gas 0.62 sp. gr. 2" Press.	Natural Gas 0.62 sp. gr. 4½ Oz. Press.
	0.120	0.0113	31	33	28	55
1/8	0.125	0.0123		36	30	58
	0.1285	0.0130	30	39	32	62
	0.136	0.0145	29	43	35	68
	0.1405	0.0155	28	44	37	72
9/64	0.1406	0.0155		45	38	74
	0.144	0.0163	27	47	39	76
	0.147	0.0174	26	48	40	78
	0.1495	0.0175	25	51	42	82
	0.152	0.0181	24	52	43	84
	0.154	0.0186	23	53	44	86
5/32	0.156	0.0192		54	45	88
	0.157	0.0192	22	55	46	90
	0.159	0.0198	21	57	47	91
	0.161	0.0203	20	58	48	94
	0.166	0.0216	19	60	50	97
	0.1695	0.0226	18	62	52	101
11/64	0.1719	0.0232		63	53	103
	0.173	0.0235	17	65	54	105
	0.177	0.0246	16	68	56	109
	0.180	0.0254	15	69	58	113
	0.182	0 0260	14	71	59	115
	0.185	0.0269	13	72	61	119
3/16	0.1875	0.0276		75	62	121
	0.189	0.0280	12	76	63	123
	0.191	0.0286	11	77	64	125
	0.1935	0.0294	10	79	66	129
	0.196	0.0302	9	80	67	131
	0.199	0.0311	8	83	69	134
	0.201	0.0317	7	84	70	136
13/64	0.203	0.0324		86	71	138
	0.204	0.0327	6	87	72	140
	0.205	0.0332	5	89	74	144
	0.209	0.0343	4	93	77	150
	0.213	0.0356	3	95	79	154
7/32	0.2187	0.0375		97	80	156
	0.221	0.0384	2	99	82	160
	0.228	0.0408	1	104	86	168
15/64	0.2344	0.0442		108	90	175
1/4	0.250	0.0491		119	99	193
17/64	0.2656	0.0554		131	109	212
9/32	0.2812	0.0621		142	119	232
19/64	0.2969	0.0692		153	128	250
5/16	0.3125	0.0767		164	136	265
21/64	0.3281	0.0845		176	146	285
11/32	0.3437	0.0928		187	155	302
23/64	0.3594	0.1014		198	165	322
3/8	0.375	0.1104		209	174	340
25/64	0.3906	0.1198		221	184	360
13/32	0.4062	0.1296		231	193	376
27/64	0.4219	0.1398		241	201	392
7/16	0.4375	0.1503		254	211	412
29/64	0.4531	0.1612		264	220	430
15/32	0.4687	0.1725		277	230	448
31/64	0.4844	0.1843		286	239	466
1/2	0.500	0.1963		299	249	485
33/64	0.5156	0.2088		309	257	500
17/32	0.5312	0.2216		320	267	520
35/64	0.5469	0.2349		331	276	539
9/16	0.5625	0.2485		340	285	556
37/64	0.5781	0.2625		353	295	576
19/32	0.5937	0.2769		365	303	590

ORIFICE CAPACITY—Continued.

Diameter Inches		Area	Morse Drill Gage Size	Cubic Feet Per Hour		
Frac.	Decimal	Square Inch		Coal Gas 0.43 sp. gr. 2" Press.	Water Gas 0.62 sp. gr. 2" Press.	Natural Gas 0.62 sp. gr. 4½ Oz. Press.
39/69	0.6094	0.2917		376	313	610
5/8	0.625	0.3068		387	323	630
41/64	0.6406	0.3223		399	333	650
21/32	0.6562	0.3382		410	341	665
43/64	0.0719	0.3546		421	350	682
11/16	0.6875	0.3712		431	369	720
45/64	0.7031	0.3883		443	370	722
23/32	0.7187	0.4057		454	378	737
47/64	0.7344	0.4236		466	387	755
3/4	0.750	0.4418		476	397	774
49/64	0.7656	0.4604		488	406	792
25/32	0.7812	0.4794		499	415	810
51/64	0.7969	0.4988		510	424	827
13/16	0.8125	0.5185		520	433	845
53/64	0.8281	0.5386		532	443	865
27/32	0.8438	0.5591		543	453	884
25/64	0.8594	0.5801		554	461	900
7/8	0.875	0.6013		565	472	920
57/64	0.8906	0.6229		576	480	938
29/32	0.9062	0.6450		588	490	955
59/64	0.9219	0.6675		599	500	976
15/16	0.9375	0.6903		610	507	985
61/64	0.9531	0.7134		620	517	1010
31/32	0.9687	0.7371		632	526	1025
63/64	0.9844	0.7611		644	536	1047
1	1.0000	0.7854		655	545	1062

NOTE:—The above table is based upon data obtained from gas orifices that are ordinarily used in gas appliances such as the ones used in Hale Gas Mixers.

ARTIFICIAL GAS:—The above figures are based upon 2-inch pressure; for higher pressures these figures should be increased by a percentage as shown below.

3-inch= 25 %
4-inch= 50
5-inch= 62.5
6-inch= 75.
7-inch= 87.5
8-inch=100.
10-inch=120
12-inch=140
16-inch=180
20-inch=210

NATURAL GAS:—The above figures for natural gas are based on a gas under 4½ oz. pressure having a specific gravity of 0.62 which is the ordinary gravity of natural gas sold in cities supplied by gas from the Mid Continent, Pennsylvania and West Virginia fields. When the pressure is greater than 4½ oz. the figures in the table should be increased as shown below.

5 oz.=10%
6 oz.=20
7 oz.=30
8 oz.=39
9 oz.=47.5
10 oz.=60

Measuring the Flow of Natural Gas

ORIFICE METER.

An instrument known as the orifice meter, for testing small flows of natural gas, is shown in figure 6. This instrument is simple in construction, consisting of a short 2-inch nipple, b, with pipe thread on one end and a thin plate disk on the other. The disk carries a 1-inch orifice, a, and a hose connection, c, for taking the pressure. The meter is especially intended for testing small gas wells and "casinghead" gas from oil wells. As a rule the flow of gas from an oil well is rather small, and it is not advisable to test the flow with a Pitot tube such as is used in testing large gas wells. In using the orifice tester, it is necessary to know the specific gravity of the gas in order to obtain the flow.

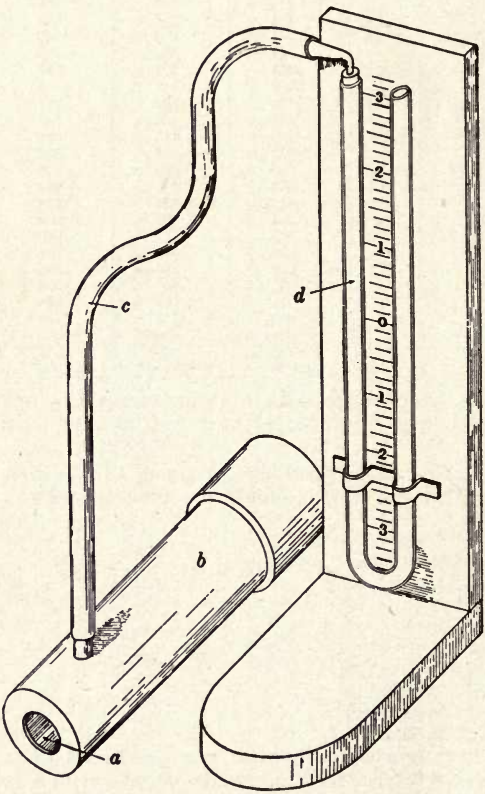


Figure 6.—Orifice meter for testing small flows of natural gas.

Before the orifice well tester is attached to the casinghead the well should be permitted to blow into the atmosphere until the head of the gas is reduced and the flow has become normal. Then the tester is attached by simply screwing it into the end of a 3-foot length of 2-inch pipe and the pressure is read in inches of water on the siphon gage, d. In the tables* on pages 133-4, the flow of the well with values for the gas of different gravities is opposite the gage reading. The orifice in the instrument should be kept dry and uninjured; otherwise the gage reading will not be correct.

*Westcott, H. P.: Handbook of Natural Gas, 1915, pp. 545-548.

Capacities of Orifices for Testing Flows of Natural Gas From Small Gas Wells and Casinghead Gas From Oil Wells.

(Temperature, 60°F.; atmospheric pressure, 14.4 pounds per square inch.)

ONE-INCH ORIFICE, IN PLATE ⅛ INCH THICK.

Pressure.	Capacity, in cubic feet per 24 hours, at specific gravity of—															
	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.3	1.4	1.5
Inches of water.																
1	26,400	25,440	24,500	23,660	22,920	22,220	21,600	21,020	20,520	20,010	19,560	19,120	18,720	18,000	17,320	16,750
2	37,510	36,040	34,750	33,600	32,520	31,530	30,640	29,800	29,080	28,360	27,720	27,120	26,540	25,480	24,570	23,760
3	46,440	44,640	43,000	41,540	40,240	39,020	37,940	36,880	36,000	35,130	34,320	33,550	32,850	31,560	30,400	29,370
4	52,630	50,590	48,740	47,060	45,600	44,200	42,980	41,800	40,800	39,790	38,880	38,040	37,220	35,760	34,460	33,310
5	57,880	55,630	53,610	51,790	50,160	48,640	47,280	45,980	44,880	43,770	42,760	41,830	40,940	39,360	37,920	36,620
6	63,140	60,720	58,480	56,490	54,720	53,060	51,600	50,180	48,960	47,760	46,650	45,640	44,680	42,960	41,370	39,960
7	68,110	65,470	63,090	60,910	59,040	57,210	55,630	54,120	52,800	51,500	50,320	49,220	48,190	46,320	44,610	43,100
8	73,050	70,220	67,680	65,350	63,310	61,390	59,680	58,050	56,640	55,240	54,000	52,800	51,690	49,690	47,850	46,220
9	77,680	74,680	72,000	69,500	67,340	65,280	63,480	61,720	60,240	58,800	57,430	56,160	54,960	52,800	50,880	49,170
10	82,340	79,150	76,270	73,650	71,370	69,190	67,270	65,420	63,840	62,280	60,860	59,520	58,240	55,900	53,920	52,100
11	86,680	83,320	80,300	77,540	75,120	72,840	70,800	68,880	67,200	65,560	64,080	62,660	61,320	58,920	56,780	54,860
12	90,720	87,190	84,000	81,140	78,600	76,220	74,110	72,000	70,320	68,610	67,030	65,560	64,170	61,680	59,400	57,400
Inches of mercury.																
½........	67,200	64,600	62,300	60,100	58,200	56,500	54,900	53,400	52,100	50,800	49,600	48,600	47,500	45,700	44,000	42,500
1	95,200	91,500	88,200	85,100	82,500	80,000	77,800	75,600	73,800	72,000	70,300	68,800	67,300	64,700	62,300	60,200
1½........	116,600	112,000	108,000	104,300	101,000	97,900	95,300	92,600	90,400	88,200	86,200	84,300	82,500	79,200	76,300	73,800
2	134,600	129,400	124,700	120,400	116,700	113,100	110,000	107,000	104,4 0	101,800	99,500	97,300	95,300	91,500	88,200	85,200
2½........	145,600	139,900	134,900	130,200	126,200	122,400	118,900	115,700	112,900	110,100	107,600	105,300	103,000	99,000	95,400	92,200
3	164,900	158,500	152,700	147,500	142,900	138,600	134,700	131,000	127,800	124,700	121,800	119,200	116,600	112,000	108,000	104,300
3½........	178,200	171,300	165,100	159,400	154,500	149,800	145,600	141,600	138,200	134,800	131,700	128,800	126,100	121,200	116,700	112,800
4	190,400	183,000	176,400	170,300	165,000	160,000	155,600	151,300	147,600	144,000	140,700	137,600	134,700	129,400	124,700	120,500
5	212,900	204,600	197,200	190,400	184,500	178,900	174,000	169,200	165,000	161,000	157,300	153,900	150,600	144,700	139,400	134,700
6	233,200	224,100	216,000	208,600	202,100	195,900	190,500	185,300	180,800	176,400	172,300	168,600	165,000	158,500	152,700	147,000
7	251,900	242,100	233,400	225,300	218,300	211,700	205,800	200,200	195,300	190,000	186,200	182,100	178,200	171,200	165,000	159,400
8	269,400	258,900	249,500	240,900	233,400	226,400	220,100	214,000	208,800	203,700	199,100	194,700	190,600	183,100	176,400	170,560
9	285,700	274,600	264,700	255,600	247,600	240,100	233,500	227,000	221,500	216,100	211,200	206,500	202,100	194,200	187,100	180,800
10	301,200	289,500	279,000	269,400	261,000	253,100	246,100	239,300	233,500	227,800	222,600	217,700	213,100	204,700	197,300	190,600
11	315,800	303,600	292,500	282,500	273,700	265,400	258,000	250,900	244,800	238,900	233,400	228,300	223,400	214,700	206,800	199,900
12	328,400	315,700	304,200	293,800	284,600	276,000	268,400	261,000	254,600	248,400	242,700	237,400	232,400	223,300	215,100	207,900

Capacities of Orifices for Testing Flows of Natural Gas From Small Gas Wells and Casinghead Gas From Oil Wells.—Continued.

ONE-HALF INCH ORIFICE, IN PLATE ½ INCH THICK.

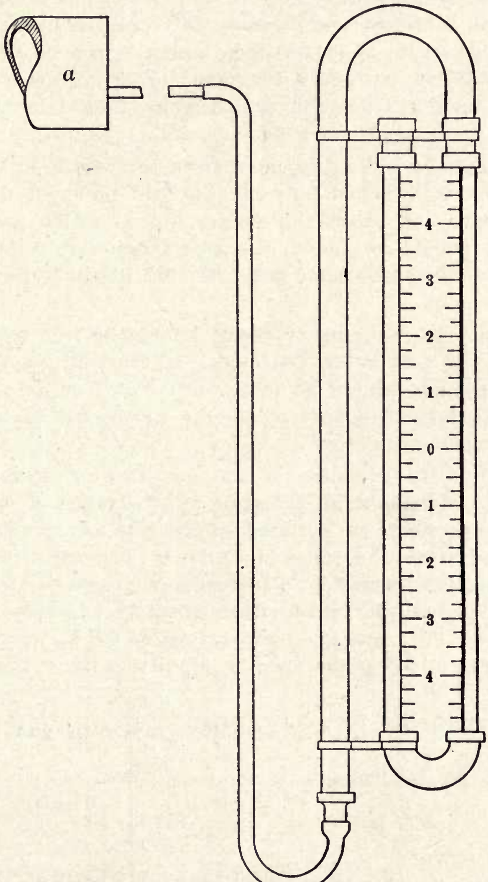
Pressure.	Capacity, in cubic feet per 24 hours, at specific gravity of—															
	0.6	.065	0.7	0.75	0.8	0.85	0.9	0.95	1	1.05	1.1	1.15	1.2	1.3	1.4	1.5
Inches of water.																
½	4,490	4,320	4,160	4,020	3,890	3,770	3,670	3,570	3,480	3,400	3,320	3,250	3,180	3,050	2,940	2,810
1	6,260	6,010	5,790	5,600	5,440	5,260	5,110	4,970	4,850	4,730	4,620	4,520	4,420	4,250	4,100	3,960
1½	7,900	7,590	7,310	7.070	6,840	6,640	6,450	6,280	6,120	5,970	5,830	5,710	5,590	5,370	5,170	5,000
2	9,140	8,780	8,460	8,170	7,910	7,680	7,460	7,260	7,080	6,910	6,750	6,600	6,460	6,210	5,980	5,780
2½	10,220	9,820	9,470	9,140	8,850	8,590	8,350	8,120	7,920	7,730	7,550	7,380	7,230	6,950	6,690	6,470
3	11,150	10,720	10,330	9,980	9,660	9,370	9,110	8,860	8,640	8,430	8,240	8,060	7,890	7,580	7,300	7,050
3½	12,020	11,550	11,130	10,750	10,410	10,100	9,810	9,550	9,310	9,090	8,880	8,680	8,500	8,170	7,870	7,600
4	12,800	12,290	11,850	11,440	11,080	10,750	10,450	10,170	9,910	9,670	9,450	9,240	9,050	8,690	8,380	8,090
4½	13,480	12,950	12,480	12,050	11,670	11,320	11,000	10,710	10,440	10,190	9,950	9,730	9,530	9,160	8,820	8,520
5	14,130	13,570	13,080	12,640	12,230	11,870	11,530	11,230	10,940	10,680	10,430	10,200	9,990	9,600	9,250	8,930
5½	14,690	14,110	13,600	13,130	12,720	12,340	11,990	11,670	11,380	11,100	10,850	10,610	10,380	9,980	9,610	9,290
6	15,210	14,620	14,080	13,610	13,170	12,780	12,420	12,090	11,780	11,500	11,230	10,990	10,760	10,330	9,960	9,620

THREE-EIGHTHS INCH ORIFICE, IN PLATE ⅜ INCH THICK.

½	2,270	2,180	2,100	2,030	1,970	1,910	1,850	1,810	1,760	1,720	1,680	1,640	1,610	1,540	1,490	1,440
1	3,460	3,320	3,200	3,090	3,000	2,910	2,820	2,750	2,680	2,670	2,550	2,500	2,450	2,350	2,260	2,190
1½	4,310	4,140	3,990	3,860	3,730	3,620	3,520	3,420	3,339	3,260	3,180	3,110	3,050	2,[illegible]30	2,820	2,730
2	4,830	4,640	4,470	4,320	4,180	4,060	3,910	3,840	3,740	3,650	3,560	3,490	3,410	3,280	3,160	3,950
2½	5,400	5,190	5,000	4,830	4,680	4,540	4,410	4,290	4,186	4,080	3,990	3,900	3,820	3,670	3,540	3,420
3	5,770	5,550	5,350	5,170	5,000	4,850	4,720	4,590	4,474	4,370	4,260	4,170	4,080	3,920	3,780	3,650
3½	6,290	6,050	5,830	5,630	5,450	5,290	5,140	5,000	4,875	4,760	4,650	4,550	4,450	4,270	4,120	3,980
4	6,650	6,390	6,160	5,950	5,760	5,590	5,430	5,280	5,152	5,030	4,910	4,800	4,700	4,520	4,350	4,210
4½	7,210	6,930	6,680	6,450	6,240	6,060	5,890	5,730	5,585	5,450	5,330	5,210	5,100	4,900	4,720	4,560
5	7,680	7,380	7,110	6,870	6,650	6,450	6,270	6,100	5,946	5,800	5,670	5,540	5,430	5,210	5,020	4,850
5½	8,100	7,790	7,500	7,250	7,020	6,810	6,620	6,440	6,278	6,130	5,980	5,850	5,730	5,510	5,310	5,130
6	8,290	7,970	7,680	7,420	7,180	6,970	6,770	6,590	6,423	6,270	6,120	5,990	5,860	5,630	5,430	5,240

Pitot Tube for Testing Open Flow of Gas Wells

The most accurate way of testing the flow of a gas well is by means of the Pitot tube, which is an instrument for determining the velocity of flowing gas by means of its momentum. The instrument,



Pitot Tube.

as shown in figure usually consists of a small tube, with one end bent at right angles, which is inserted in the flowing gas, just inside the pipe or tubing *a*, at a point between one-third and one-fourth of

the pipe's diameter from the outer edge of the pipe. The plane of the opening in the tube is held at right angles to the flowing gas. At a convenient distance, varying from 1 to 2 feet, an inverted siphon or U-shaped gage, usually half filled with mercury or water, is attached to the other end. If the pressure of the flow is more than 5 pounds per square inch, a pressure gage is required.

In small-sized wells with a flow of not more than 4,000,000 cubic feet per 24 hours, a 12-inch U-gage with water can be used; for flows ranging from 4,000,000 to 15,000,000 feet, mercury in a 12-inch U-gage; for 15,000,000 to 35,000,000 feet, a 50-pound spring gage, and for more than 35,000,000 feet, a 100-pound spring gage should be used. The foregoing figures are based on a 6-inch hole.

For convenience, a scale graduated from the center in inches and tenths of an inch is attached between the two limbs of the U-gage. The distance above and below this center line at which the liquid in the gage stands should be added, the object being to determine the exact distance between the high and low side of the fluid in inches and tenths of an inch.

The top joint of the tubing or casing should be free from fittings for a distance of 10 feet below the mouth of the well where the test is made. The test should not be made in a collar or gate or at the mouth of any fitting. The well should be blown off at least three hours prior to making the test.

After the velocity pressure of the gas flowing from the well tubing has been determined in inches of water, inches of mercury, or pounds per square inch, as outlined above, the corresponding flow may be obtained from the following table*. The quantities of gas stated in the table are based on a pressure of 4 ounces above atmospheric, or 14.65 pounds per square inch absolute pressure, a flowing temperature of 60° F., a storage temperature of 60° F., and a specific gravity of 0.60 (air = 1). If the specific gravity is other than 0.60 the flow should be multiplied by $\sqrt{\frac{0.60}{\text{specific gravity of gas}}}$.

*Westcott, H. P.: Handbook of Natural Gas, 1915, pp. 176, 177.

Table for Determining Flow of Gas Wells by Means of Pitot Tube.

(Figures show the rate of flow of gas of 0.6 specific gravity from gas well tubing of different sizes in cubic feet per 24 hours for different pressures.)

Pressure.			Volume of gas, in cubic feet per 24 hours, discharged through—				Pressure.	Volume of gas, in cubic feet per 24 hours, discharged through—			
Inches of water.	Inches of mercury.	Pounds per square inch.	1-inch tubing.	2-inch tubing.	3-inch tubing.	4-inch tubing.	Pounds per square inch.	1-inch tubing.	2-inch tubing.	3-inch tubing.	4-inch tubing.
0.10	....	....	11,880	47,520	106,920	190,080	2.75	321,000	1,284,000	2,889,000	5,136,000
.20	....	....	17,136	68,544	154,224	274,176	3.	340,200	1,360,800	3,061,800	5,443,200
.30	....	....	20,568	82,272	185,112	329,088	3.25	354,120	1,416,480	3,187,080	5,665,920
.40	....	....	23,520	94,080	211,680	376,320	3.50	367,680	1,470,720	3,309,120	5,882,880
.50	....	....	26,544	106,176	238,896	424,704	3.75	380,400	1,521,600	3,423,600	6,086,400
.60	....	....	29,112	116,448	262,008	465,792	4.00	392,880	1,571,520	3,535,920	6,286,080
.7	....	....	31,440	125,760	282,960	503,040	4.25	405,000	1,620,000	3,645,000	6,480,000
.8	....	....	33,624	134,496	302,616	537,984	4.50	416,640	1,666,560	3,749,760	6,666,240
.9	....	....	35,640	142,560	320,760	570,240	4.75	428,280	1,713,120	3,854,520	6,852,480
1.0	....	....	37,320	149,280	335,880	597,120	5.00	439,920	1,759,680	3,959,280	7,038,720
1.25	....	....	41,712	166,848	375,408	667,392	6	476,040	1,904,160	4,284,360	7,616,640
1.5	....	....	45,960	183,840	413,640	735,360	7	517,320	2,069,280	4,655,880	8,277,120
1.75	0.12	....	49,680	198,720	447,120	794,880	8	542,400	2,169,600	4,881,600	8,678,400
2.0	.147	....	53,136	212,544	478,224	850,176	9	569,640	2,278,650	5,126,760	9,114,240
2.5	.184	....	59,400	237,600	534,600	950,400	10	595,560	2,382,240	5,360,040	9,528,960
3.0	.22	.108	65,088	260,352	585,792	1,041,408	11	621,960	2,487,840	5,597,640	9,951,360
3.5	.257	.126	70,272	281,088	632,448	1,124,352	12	642,600	2,570,400	5,783,400	10,281,600
4.0	.294	.144	75,120	300,480	676,080	1,201,920	13	664,680	2,658,720	5,982,120	10.634,880
4.5	.331	.162	79,704	318,810	717,336	1,275,264	14	683,880	2,735,520	6,154,920	10,942,080
5.0	.368	.18	84,000	336,000	756,000	1,344,000	15	703,080	2,812,320	6,327,720	11,249,280
6.	.441	.216	92,016	368,060	828,144	1,472,256	16	721,080	2,884,320	6,489,720	11,537,280
7.	.515	.252	99,360	397,440	894,240	1,589,760	17	738,120	2,952,480	6,643,080	11,809,920
8.	.588	.288	106,272	425,088	956,448	1,700,352	18	753,960	3,015,840	6,785,640	12,063,360
9.	.662	.324	112,656	450,624	1,013,904	1,802,496	20	785,520	3,142,080	7,069,680	12,568,320
10.	.736	.36	118,800	475,200	1,069,200	1,900,800	22	803,280	3,213,120	7,229,520	12,852,480
11.	.8	.396	125,160	500,640	1,126,440	2,002,560	25	854,880	3,419,520	7,693,920	13,678,080
12.	.88	.432	130,128	520,512	1,171,152	2,082,048	30	910,680	3,642,720	8,196,120	14,570,880
....	1.02	.5	138,960	555,840	1,250,640	2,223,360	35	960,960	3,843,840	8,648,640	15,375,360
....	.152	.75	170,280	681,120	1,532,520	2,724,480	40	1,006,680	4,026,720	9,060,120	16,106,880
....	2.03	1.00	196,680	786,720	1,770,120	3,146,880	45	1,046,520	4,186,080	9,418,680	16,744,320
....	2.54	1.25	219,960	879,840	1,979,640	3,519,360	50	1,081,920	4,327,680	9,737,280	17,310,720
....	3.05	1.5	240,720	962,880	2,166,480	3,851,520	60	1,137,120	4,548,480	10,234,080	18,193,920
....	3.56	1.75	259,920	1,039,680	2,339,280	4,158,720	75	1,223,400	4,893,600	11,010,600	19,574,400
....	4.07	2.00	272,640	1,090,560	2,453,760	4,362,240	90	1,304,400	5,217,600	11,739,600	20,870,400
....	4.57	2.25	294,600	1,178,400	2,651,400	4,713,600	100	1,336,920	5,317,680	12,032,280	21,390,720
....	5.08	2.50	310,800	1,243,200	2,797,200	4,972,800					

For pipe diameters other than those given in the preceding table, the following multipliers should be applied to the figures for 1-inch tubing given in the table.

Multipliers for Pipe Diameters Ranging from 1½ to 12 inches.

Diameter of pipe, inches.	Multiplier.	Diameter of pipe, inches.	Multiplier.	Diameter of pipe, inches.	Multiplier.
1½	2.25	5	25	8	64
2½	6.25	5⅝	31.64	8¼	68
4¼	18	6	36	9	81
4⅝	21.39	6¼	39	10	100
		6⅝	43.9	12	144

Capacity of Pipe Lines

(Metric Metal Works.)

Tables to Find the Cubic Feet, per Day of 24 Hours, of Gas of .6 Specific Gravity at Certain Pressure in Pipe Lines of Various Diameter and Lengths.

Select in table A the number opposite the gauge pressures, in pounds, then from table B select the number opposite the length of line in miles. Multiply these two numbers together and result is the cubic feet that a 1-inch line will discharge for the pressures and length named in twenty-four hours. If the diameter of the pipe is other than one inch, select the number in table C which corresponds with the diameter and multiply this number by the discharge for one inch already secured. The result is the quantity in cubic feet in twenty-four hours discharged by a line whose diameter was selected.

If there are other pressures and lengths not given in the table they can be secured by interpolation. Example—Suppose it is required to find the discharge per day of twenty-four hours of a pipe line having an intake of 200-pound gauge pressure and 25 pounds at the discharge end, the length being 20 miles, and the diameter 8 inches. In table A we find opposite 200 and 25 the number 211.25, and in table B opposite 20 miles, 22.5, multiplying these two numbers the result being 47,637 cubic feet that under the above condition of pressure and length a 1-inch pipe would convey, but the required diameter is 8 inches. Under this number in table C it will be found that 198 corresponds; therefore 47,637×198=9,433,126, which is the cubic feet discharged in 24 hours.

If the pressure were twenty pounds instead of twenty-five at the discharge end it would be found very closely by adding the figures opposite 15 and 25 and dividing by 2, the result would be 9,469,154.

Table A

Intake, lbs.	Discharge, lbs.	Resultant	Intake, lbs.	Discharge, lbs.	Resultant	Intake, lbs.	Discharge, lbs.	Resultant
1	¼	4.7	15	1	25.4	60	5	72.3
1	½	3.9	15	3	24.0	60	10	70.7
2	½	6.9	15	6	21.4	60	15	68.8
2	1	4.7	15	9	18.0	60	20	66.3
2	1½	4.0	15	12	13.1	60	25	63.4
3	1	8.1	20	1	31.1	60	30	60.0
3	2	5.8	20	4	29.4	60	40	51.0
4	1	10.1	20	8	26.4	60	50	37.4
4	2	8.4	20	10	24.5	60	55	26.9
4	3	6.0	20	15	18.0	70	5	82.6
5	1	11.8	20	18	11.7	70	10	81.2
5	2	10.4	25	1	36.7	70	20	77.5
5	3	8.6	25	3	35.7	70	30	72.1
5	4	6.2	25	6	34.0	70	40	64.8
6	1	13.4	25	10	31.2	70	50	54.7
6	3	10.6	25	15	26.5	70	60	40.0
6	5	6.3	25	18	22.6	80	5	92.8
7	1	14.9	30	1	42.1	80	10	91.6
7	3	12.5	30	3	41.2	80	20	88.3
7	5	9.0	30	6	39.8	80	30	83.7
7	6	6.5	30	10	37.4	80	40	77.5
8	1	16.3	30	15	33.5	80	50	69.2
8	3	14.1	30	20	28.3	80	60	58.3
8	5	11.2	30	25	20.0	80	70	42.4
8	7	6.6	40	5	51.2	90	5	103.1
9	1	17.6	40	10	49.0	90	10	102.0
9	3	15.6	40	15	46.1	90	20	99.0
9	5	13.1	40	20	42.4	90	30	94.9
9	8	6.8	40	25	37.8	90	40	89.4
10	1	19.2	40	30	31.6	90	50	82.5
10	2	18.3	40	35	22.9	90	60	73.5
10	4	16.3	50	5	61.8	90	70	61.6
10	6	13.6	50	10	60.0	90	80	44.7
10	8	9.8	50	15	57.7	100	5	113.3
10	9	7.0	50	20	54.8	100	10	112.3
12	1	21.8	50	25	51.2	100	15	111.0
12	3	20.1	50	30	46.9	100	20	109.5
12	6	17.0	50	35	41.5	100	25	107.8
12	8	14.1	50	40	34.6	100	35	103.6
12	10	10.2	50	45	25.0	100	50	94.9

TABLE A—Continued.

Intake, lbs.	Discharge, lbs.	Resultant	Intake, lbs.	Discharge, lbs.	Resultant	Intake, lbs.	Discharge, lbs.	Resultant
100	75	71.6	175	100	151.2	250	100	238.8
100	85	56.8	175	150	94.2	250	125	225.0
100	95	33.5	200	5	214.1	250	150	207.4
110	5	123.4	200	15	212.9	250	175	184.7
110	15	121.4	200	25	211.3	250	200	154.9
110	25	118.4	200	35	209.1	250	230	101.0
110	35	114.6	200	50	204.9	275	5	289.3
110	50	106.8	200	75	195.3	275	15	288.4
110	75	86.8	200	100	181.7	275	25	287.2
110	85	75.0	200	125	163.2	275	35	285.7
110	100	49.0	200	150	137.9	275	50	282.6
125	5	138.6	200	175	100.6	275	75	275.7
125	15	136.8	200	190	64.8	275	100	266.2
125	25	134.2	220	5	234.2	275	150	238.5
125	35	130.8	220	15	233.1	275	200	194.6
125	50	124.0	220	25	231.6	275	250	117.8
125	75	107.2	220	35	229.6	300	5	314.4
125	100	79.8	220	50	225.8	300	15	313.6
125	110	63.1	220	75	217.1	300	25	312.5
135	5	148.7	220	100	204.9	300	35	311.0
135	15	147.0	220	125	188.8	300	50	308.2
135	25	144.6	220	150	167.3	300	75	301.9
135	35	141.4	220	175	138.3	300	100	293.8
135	50	135.2	220	200	94.9	300	125	282.2
135	75	120.0	230	5	244.1	300	150	268.3
135	100	96.3	230	15	243.2	300	175	251.3
150	5	163.8	230	25	241.7	300	200	230.2
150	15	162.3	230	35	239.8	300	250	170.3
150	25	160.1	230	50	236.2	300	275	123.0
150	40	155.6	230	75	227.9	325	5	339.4
150	50	151.7	230	100	216.3	325	15	338.7
150	75	138.3	230	150	181.5	325	25	337.6
150	100	118.3	230	200	117.5	325	35	336.3
150	120	94.9	230	215	84.4	325	50	333.7
175	5	188.9	250	5	264.2	325	75	327.9
175	15	187.6	250	15	263.3	325	100	320.0
175	25	185.7	250	25	262.0	325	125	309.8
175	35	183.3	250	35	260.2	325	150	297.3
175	50	178.5	250	50	256.9	325	175	281.9
175	75	167.3	250	75	249.3	325	200	263.4

TABLE A—Continued.

Intake, lbs.	Discharge, lbs.	Resultant	Intake, lbs.	Discharge, lbs.	Resultant	Intake, lbs.	Discharge, lbs.	Resultant
325	250	213.0	375	250	286.1	425	175	396.9
325	275	177.5	375	275	260.8	425	200	383.9
325	285	160.0	375	300	230.0	425	225	368.8
325	300	128.0	375	325	191.1	425	250	351.3
350	5	364.5	375	350	137.4	425	275	330.9
350	15	363.8	400	5	414.5	425	300	307.2
350	25	362.8	400	15	413.9	425	325	279.3
350	35	361.6	400	25	413.1	425	350	245.7
350	50	359.2	400	35	412.0	425	375	203.7
350	75	353.7	400	50	409.9	425	400	146.2
350	100	346.4	400	75	405.1	450	5	464.6
350	125	337.1	400	100	398.8	450	15	464.0
350	150	325.6	400	125	390.2	450	25	463.3
350	175	311.7	400	150	380.8	450	35	462.3
350	200	295.0	400	175	369.0	450	50	460.4
350	225	275.0	400	200	355.0	450	75	456.2
350	250	251.0	400	225	338.6	450	100	450.5
350	275	221.6	400	250	319.4	450	125	443.4
350	300	184.4	400	275	296.9	450	150	431.7
350	325	132.8	400	300	270.2	450	175	424.4
375	5	389.5	400	325	238.0	450	200	412.3
375	15	388.8	400	350	197.5	450	225	398.3
375	25	387.9	400	375	141.9	450	250	382.1
375	35	386.8	425	5	439.6	450	275	363 5
375	50	384.6	425	15	439.0	450	300	342.1
375	75	379.5	425	25	438.2	450	325	317.2
375	100	372.7	425	35	437.2	450	350	288.1
375	125	364.0	425	50	435.2	450	375	253 2
375	150	353.4	425	75	430.7	450	400	209.8
375	175	340.6	425	100	424.7	450	425	150.4
375	200	325.4	425	125	417.1	475	50	485.7
375	225	307.4	425	150	407.9	500	50	510.0

Table B

Miles	Multipliers	Miles	Multipliers	Miles	Multipliers
⅛	2880.	19	231.2	61	129.1
¼	2016.	20	225.5	62	128.1
⅜	1652.4	21	220.1	63	126.9
½	1419.7	22	214.9	64	126.0
⅝	1275.9	23	210.0	65	125.1
¾	1158.6	24	205.7	66	124.1
⅞	1083.7	25	201.6	67	123.1
1	1008.0	26	197.6	68	122.2
1½	826.2	27	193.8	69	121.3
1¾	763.6	28	190.5	70	120.4
2	714.9	29	187.0	72	118.7
2½	638.0	30	183.9	74	117.2
2¾	607.2	31	181.0	76	115.6
3	582.7	32	178.0	78	114.2
3½	539.0	33	175.6	80	112.7
4	504.0	34	172 9	82	111.2
4½	475.5	35	170.3	84	109.9
5	450.0	36	168.0	86	108.7
5½	428.9	37	165.8	88	107.5
6	411.4	38	163.6	90	106 2
6½	395.3	39	161.3	92	105.1
7	380.4	40	159 5	94	103.9
7½	367.9	41	157.5	96	102.9
8	356.2	42	155.6	98	101.8
8½	345.2	43	153.7	100	100 8
9	336.0	44	152.0	102	99.8
9½	327.3	45	150.2	105	98.3
10	319.0	46	148.7	107	97.5
10½	311.1	47	146.9	110	96 0
11	303.6	48	145.4	112	95.3
11½	297.3	49	144.0	115	93 9
12	291.3	50	142 6	118	92.8
12½	284.7	51	141.2	120	92.0
13	276.4	52	139.8	122	91.2
13½	274.6	53	138.5	125	90 2
14	269.5	54	137.1	130	88.4
14½	264.6	55	135.8	135	86.8
15	260.5	56	134.8	140	85.2
15½	255.8	57	133.5	145	83.7
16	252.0	58	132.3	150	82.3
17	244.7	59	131.2	...	.....
18	237.5	60	130.1	...	.....

Table C

Multipliers for diameters other than 1 inch.

¼ inch= .0317	3 inch= 16.50	12 inch= 556
½ inch= .1810	4 inch= 34.10	16 inch=1160
¾ inch= .5012	5 inch= 60.00	18 inch=1570
1 inch= 1.0000	5⅝ inch= 81.00	20 inch=2055
1½ inch= 2.9300	6 inch= 95.00	24 inch=3285
2 inch= 5.9200	8 inch=198.00	30 inch=5830
2½ inch=10.3700	10 inch=350.00	36 inch=9330

For wrought iron pipes greater than 12 inches in diameter the measure is taken from the outside, and for pipes of ordinary thickness the corresponding inside diameters and multipliers are as follows:

Outside dia. of 15-inch pipe gives 14¼ in. inside dia.= 863
Outside dia. of 16-inch pipe gives 15¼ in. inside dia.=1025
Outside dia. of 18-inch pipe gives 17¼ in. inside dia.=1410
Outside dia of 20-inch pipe gives 19¼ in. inside dia.=1860

Method of Reading the Hydrometer

The correct method of reading the hydrometer is illustrated in Figures 1 and 2. The sample of oil is placed in a clear glass jar or cylinder and the hydrometer carefully immersed in it to a point slightly below that to which it naturally sinks, and is then allowed to float freely.

The reading should not be taken until the oil and the hydrometer are free from air bubbles and are at rest.

In taking the reading the eye should be placed slightly below the plane of the surface of the oil (Figure 1) and then raised slowly until this surface, seen as an ellipse, becomes a straight line (Figure 2). The point at which this line cuts the hydrometer scale should be taken as the reading of the instrument (Figure 2).

In case the oil is not sufficiently clear to allow the reading to be made as above described, it will be necessary to read from above the oil surface and to estimate as accurately as possible the point to which the oil rises on the hydrometer stem. It should be remembered, however, that the instrument is calibrated to give correct indications when read at the principal surface of the liquid. It will be necessary, therefore, to correct the reading at the upper meniscus by an amount equal to the height to which the oil creeps up on the stem of the hydrometer. The amount of this correction may be determined with sufficient accuracy for most purposes by taking a few readings on the upper and the lower meniscus in a clear oil and noting the differences.

A specific gravity hydrometer will read too low and a Baume′ hydrometer too high when read at the upper edge of the meniscus. The correction for meniscus height should therefore be added to a specific gravity reading and subtracted from a Baume′ reading.

The magnitude of the correction will obviously depend upon the length and value of the subdivisions of the hydrometer scale and must be determined in each case for the particular hydrometer in question.

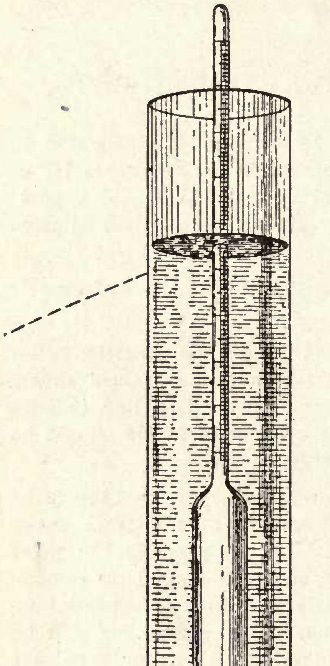


FIG. 1.

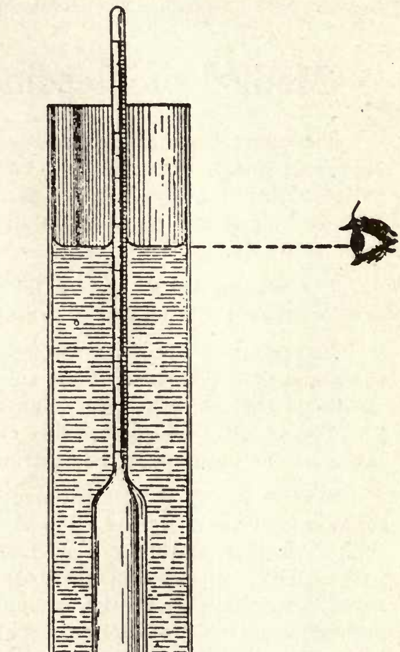


FIG. 2.

BAUME', SPECIFIC GRAVITY AND POUNDS PER GALLON.

(U. S. Standard Tables.)

	0	1	2	3	4	5	6	7	8	9
10	1.0000	.9993	.9986	.9979	.9972	.9964	.9957	.9950	.9943	.9936
	8.325	8.322	8.317	8.311	8.305	8.299	8.293	8.287	8.281	8.275
11	.9929	.9922	.9915	.9908	.9901	.9894	.9887	.9880	.9873	.9866
	8.269	8.263	8.258	8.252	8.246	8.240	8.234	8.228	8.223	8.217
12	.9859	.9852	.9845	.9838	.9831	.9825	.9818	.9811	.9804	.9797
	8.211	8.205	8.199	8.194	8.188	8.182	8.176	8.171	8.165	8.159
13	.9790	.9783	.9777	.9770	.9763	.9756	.9749	.9743	.9736	.9729
	8.153	8.148	8.142	8.137	8.131	8.125	8.119	8.114	8.108	8.102
14	.9722	.9715	.9709	.9702	.9695	.9688	.9682	.9675	.9669	.9662
	8.096	8.091	8.086	8.080	8.074	8.069	8.063	8.058	8.052	8.047
15	.9655	.9649	.9642	.9635	.9629	.9622	.9615	.9609	.9602	.9596
	8.041	8.035	8.030	8.024	8.019	8.013	8.007	8.002	7.997	7.991
16	.9589	.9582	.9576	.9569	.9563	.9556	.9550	.9543	.9537	.9530
	7.986	7.980	7.975	7.969	7.964	7.959	7.953	7.948	7.942	7.937
17	.9524	.9517	.9511	.9504	.9498	.9492	.9485	.9479	.9472	.9466
	7.931	7.926	7.921	7.915	7.910	7.904	7.899	7.894	7.888	7.883
18	.9459	.9453	.9447	.9440	.9434	.9428	.9421	.9415	.9409	.9402
	7.877	7.872	7.867	7.861	7.856	7.851	7.846	7.841	7.835	7.830
19	.9396	.9390	.9383	.9377	.9371	.9365	.9358	.9352	.9346	.9340
	7.825	7.820	7.814	7.809	7.804	7.799	7.793	7.788	7.783	7.778
20	.9333	.9327	.9321	.9315	.9309	.9302	.9296	.9290	.9284	.9278
	7.772	7.767	7.762	7.757	7.752	7.747	7.742	7.736	7.731	7.726
21	.9272	.9265	.9259	.9253	.9247	.9241	.9235	.9229	.9223	.9217
	7.721	7.716	7.711	7.706	7.701	7.696	7.690	7.685	7.680	7.675
22	.9211	.9204	.9198	.9192	.9186	.9180	.9174	.9168	.9162	.9156
	7.670	7.665	7.660	7.655	7.650	7.645	7.640	7.635	7.630	7.625
23	.9150	.9144	.9138	.9132	.9126	.9121	.9115	.9109	.9103	.9097
	7.620	7.615	7.610	7.605	7.600	7.595	7.590	7.585	7.580	7.575
24	.9091	.9085	.9079	.9073	.9067	.9061	.9056	.9050	.9044	.9038
	7.570	7.565	7.561	7.556	7.551	7.546	7.541	7.536	7.531	7.526
25	.9032	.9026	.9021	.9015	.9009	.9003	.8997	.8992	.8986	.8980
	7.522	7.517	7.512	7.507	7.502	7.497	7.493	7.488	7.483	7.478
26	.8974	.8969	.8963	.8957	.8951	.8946	.8940	.8934	.8929	.8923
	7.473	7.469	7.464	7.459	7.454	7.449	7.445	7.440	7.435	7.430
27	.8917	.8912	.8906	.8900	.8895	.8889	.8883	.8878	.8872	.8866
	7.425	7.421	7.416	7.411	7.407	7.402	7.397	7.393	7.388	7.383
28	.8861	.8855	.8850	.8844	.8838	.8833	.8827	.8822	.8816	.8811
	7.378	7.374	7.369	7.365	7.360	7.355	7.351	7.346	7.341	7.337
29	.8805	.8799	.8794	.8788	.8783	.8777	.8772	.8766	.8761	.8755
	7.332	7.328	7.323	7.318	7.314	7.309	7.305	7.300	7.295	7.291
30	.8750	.8745	.8739	.8734	.8728	.8723	.8717	.8712	.8706	.8701
	7.286	7.282	7.277	7.273	7.268	7.264	7.259	7.254	7.249	7.245
31	.8696	.8690	.8685	.8679	.8674	.8669	.8663	.8658	.8653	.8647
	7.241	7.236	7.232	7.227	7.223	7.218	7.214	7.210	7.205	7.201
32	.8642	.8637	.8631	.8626	.8621	.8615	.8610	.8605	.8600	.8594
	7.196	7.192	7.187	7.183	7.178	7.173	7.169	7.165	7.161	7.156
33	.8589	.8584	.8578	.8573	.8568	.8563	.8557	.8552	.8547	.8542
	7.152	7.147	7.143	7.139	7.134	7.130	7.125	7.121	7.117	7.113
34	.8537	.8531	.8526	.8521	.8516	.8511	.8505	.8500	.8495	.8490
	7.108	7.104	7.100	7.095	7.091	7.087	7.082	7.078	7.074	7.069
35	.8485	.8480	.8475	.8469	.8464	.8459	.8454	.8449	.8444	.8439
	7.065	7.061	7.057	7.052	7.048	7.044	7.039	7.035	7.031	7.027
36	.8434	.8429	.8424	.8419	.8413	.8408	.8403	.8398	.8393	.8388
	7.022	7.018	7.014	7.010	7.006	7.001	6.997	6.993	6.989	6.985
37	.8383	.8378	.8373	.8368	.8363	.8358	.8353	.8348	.8343	.8338
	6.980	6.976	6.972	6.968	6.964	6.960	6.955	6.951	6.947	6.943
38	.8333	.8328	.8323	.8318	.8314	.8309	.8304	.8299	.8294	.8289
	6.939	6.935	6.930	6.926	6.922	6.918	6.914	6.910	6.906	6.902

BAUME', SPECIFIC GRAVITY AND POUNDS PER GALLON—Con.

	0	1	2	3	4	5	6	7	8	9
39	.8284	.8279	.8274	.8269	.8264	.8260	.8255	.8250	.8245	.8240
	6.898	6.894	6.889	6.885	6.881	6.877	6.873	6.869	6.865	6.861
40	.8235	.8230	.8226	.8221	.8216	.8211	.8206	.8202	.8197	.8192
	6.857	6.853	6.849	6.845	6.841	6.837	6.833	6.829	6.825	6.821
41	.8187	.8182	.8178	.8173	.8168	.8163	.8159	.8154	.8149	.8144
	6.817	6.813	6.809	6.805	6.801	6.797	6.793	6.789	6.785	6.781
42	.8140	.8135	.8130	.8125	.8121	.8116	.8111	.8107	.8102	.8097
	6.777	6.773	6.769	6.765	6.761	6.758	6.754	6.750	6.746	6.742
43	.8092	.8088	.8083	.8078	.8074	.8069	.8065	.8060	.8055	.8051
	6.738	6.734	6.730	6.726	6.722	6.718	6.715	6.711	6.707	6.703
44	.8046	.8041	.8037	.8032	.8028	.8023	.8018	.8014	.8009	.8005
	6.699	6.695	6.691	6.688	6.684	6.680	6.676	6.672	6.668	6.665
45	.8000	.7995	.7991	.7986	.7982	.7977	.7973	.7968	.7964	.7959
	6.661	6.657	6.653	6.649	6.646	6.642	6.638	6.634	6.630	6 627
46	.7955	.7950	.7946	.7941	.7937	.7932	.7928	.7923	.7919	.7914
	6.623	6.619	6.616	6.612	6.608	6.604	6 600	6.597	6.593	6.589
47	.7910	.7905	.7901	.7896	.7892	.7887	.7883	.7878	.7874	.7870
	6.586	6.582	6.578	6.574	6.571	6.567	6.563	6.560	6.556	6.552
48	.7865	.7861	.7856	.7852	.78 8	.7843	.7839	.7834	.7830	.7826
	6.548	6.545	6.541	6.537	6.534	6.530	6.526	6.523	6.519	6.515
49	.7821	.7817	.7812	.7808	.7804	.7799	.7795	.7791	.7786	.7782
	6.511	6.508	6.504	6.501	6.497	6.494	6.490	6.486	6.483	6.479
50	.7778	.7773	.7769	.7765	.7761	.7756	.7752	.7748	.7743	.7739
	6.476	6.472	6.468	6.465	6.461	6.458	6.454	6.450	6.447	6.443
51	.7735	.7731	.7726	.7722	.7717	.7713	.7709	.7705	.7701	.7697
	6.440	6.436	6.432	6.429	6.425	6.421	6.418	6.415	6 411	6.408
52	.7692	.7688	.7684	.7680	.7675	.7671	.7667	.7663	.7659	.7654
	6.404	6.401	6.397	6.394	6.390	6.387	6.383	6.380	6.376	6.373
53	.7650	.7646	.7642	.7638	.7634	.7629	.7625	.7621	.7617	.7613
	6.369	6.366	6.362	6.359	6.355	6.351	6.348	6.345	6.341	6 338
54	.7609	.7605	.7600	.7596	.7592	.7588	.7584	.7580	.7576	.7572
	6.334	6.331	6.327	6.324	6.321	6.317	6.314	6.311	6.307	6.304
55	.7568	7.563	.7559	.7555	.7551	.7547	.7543	.7539	.7535	.7531
	6.300	6.296	6.293	6.290	6.287	6.283	6.280	6.276	6 273	6.270
56	.7527	.7523	.7519	.7515	.7511	.7507	.7503	.7499	.7495	.7491
	6.266	6.263	6.259	6.256	6.253	6.249	6.246	6.243	6.240	6.236
57	.7487	.7483	.7479	.7475	.7471	.7467	.7463	.7459	.7455	.7451
	6.233	6.229	6.226	6.223	6.219	6.216	6.213	6.209	6.206	6.203
58	.7447	.7443	.7439	.7435	.7431	.7427	.7423	.7419	.7415	.7411
	6.199	6.196	6.193	6.190	6.186	6.183	6.180	6.176	6.173	6.170
59	.7407	.7403	.7400	.7396	.7392	.7388	.7384	.7380	.7376	.7372
	6.166	6.163	6.160	6.157	6.154	6.150	6.147	6.144	6.141	6.137
60	.7368	.7365	.7361	.7357	.7353	.7349	.7345	.7341	.7338	.7334
	6.134	6.131	6.128	6.124	6.121	6.118	6.115	6.112	6.108	6.105
61	.7330	.7326	.7322	.7318	.7315	.7311	.7307	.7303	.7299	.7295
	6.102	6.099	6.096	6.093	6.090	6.086	6.983	6.080	6 077	6.073
62	.7292	.7288	.7284	.7280	.7277	.7273	.7269	7265	.7261	.7258
	6.070	6.067	6.064	6.060	6.057	6.054	6.051	6.948	6.015	6.0 2
63	.7254	.7250	.7246	.7243	.7239	.7235	.7231	.7228	.7224	.7220
	6.038	6.035	6.032	6.029	6.026	6.023	6.020	6.017	6 014	6.010
64	.7216	.7213	.7209	.7205	.7202	.7198	.7194	.7191	.7187	.7183
	6.007	6.004	6.001	5.998	5.995	5.992	5.989	5.986	5.983	5.980
65	.7179	.7176	.7172	.7168	7165	.7161	.7157	.7154	.7150	.7147
	5.976	5.973	5.970	5.967	5.964	5.961	5.958	5.955	5.952	5.949
66	.7143	.7139	.7136	.7132	.7128	.7125	.7121	.7117	.7114	.7110
	5.946	5.943	5.940	5.937	5.934	5.931	5.928	5.925	5.922	5.919
67	.7107	.7103	.7099	.7096	.7092	.7089	.7085	.7081	.7078	.7074
	5.916	5.913	5.910	5.907	5.904	5.901	5.898	5.895	5.892	5.889

BAUME', SPECIFIC GRAVITY AND POUNDS PER GALLON—Con.

	0	1	2	3	4	5	6	7	8	9
68	.7071	.7067	.7064	.7060	.7056	.7053	.7049	.7046	.7042	.7039
	5.886	5.883	5.880	5.877	5.874	5.871	5.868	5.865	5.862	5.859
69	.7035	.7032	.7028	.7025	.7021	.7018	.7014	.7011	.7007	.7004
	5.856	5.853	5.850	5.848	5.845	5.842	5.839	5.836	5.833	5.830
70	.7000	.6997	.6993	.6990	.6986	.6983	.6979	.6976	.6972	.6669
	5.827	5.824	5.821	5.818	5.815	5.812	5.810	5.807	5.804	5.801
71	.6965	.6962	.6958	.6955	.6951	.6948	.6944	.6941	.6938	.6934
	5.798	5.795	5.792	5.789	5.786	5.784	5.781	.5.778	5.775	5.772
72	.6931	.6927	.6924	.6920	.6917	.6914	.6910	.6907	.6903	.6900
	5.769	5.766	5.763	5.760	5.758	5.755	5.752	5.749	5.746	5.744
73	.6897	.6893	.6890	.6886	.6883	.6880	.6876	.6873	.6869	.6866
	5.741	5.738	5.735	5.732	5.729	5.727	5.724	5.721	5.718	5 715
74	.6863	.6859	.6856	.6853	.6849	.6846	.6843	.6839	.6836	.6833
	5.712	5.710	5.707	5.704	5.701	5.698	5.696	5.693	5.690	5.687
75	.6829	.6826	.6823	.6819	.6816	.6813	.6809	.6806	.6803	.6799
	5.685	5.682	5.679	5.676	5.673	5.671	5.668	5.665	5.662	5.660
76	.6796	.6793	.6790	.6786	.6783	.6780	.6776	.6773	.6770	.6767
	5.657	5.654	5.652	5.649	5.646	5.643	5.640	5.638	5.635	5 632
77	.6763	.6760	.6757	.6753	.6750	.6747	.6744	.6740	.6737	.6734
	5.629	5.627	5.624	5.621	5.618	5.616	5.613	5.610	5.608	5.605
78	.6731	.6728	.6724	.6721	.6718	.6715	.6711	.6708	.6705	.6702
	5.602	5.600	5.597	5.594	5.592	5.589	5.586	5.584	5.581	5.578
79	.6699	.6695	.6692	.6689	.6686	.6683	.6679	.6676	.6673	.6670
	5.576	5.573	5.570	5.568	5.565	5.562	5.560	5.557	5.554	5.552
80	.6667	.6663	.6660	.6657	.6654	.6651	.6648	.6645	.6641	.6638
	5.549	5.546	5.543	5.541	5.538	5.536	5.533	5.531	5.528	5 525
81	.6635	.6632	.6629	.6626	.6623	.6619	.6616	.6613	.6610	.6607
	5.522	5.520	5.517	5.515	5.512	5.510	5.507	5.504	5.502	5.499
82	.6604	.6601	.6598	.6594	.6591	.6588	.6585	.6582	.6579	.6576
	5.497	5.494	5.491	5.489	5.486	5.484	5.481	5.478	5.476	5.473
83	.6573	.6570	.6567	.6564	.6560	.6557	.6554	.6551	.6548	.6545
	5.471	5.468	5.466	5.463	5.460	5.458	5.455	5.453	5.450	5.448
84	.6542	.6539	.6536	.6533	.6530	.6527	.6524	.6521	.6518	.6515
	5.445	5.443	5.440	5.437	5.435	5.432	5.430	5.427	5.425	5.422
85	.6512	.6509	.6506	.6503	.6500	.6497	.6494	.6490	.6487	.6484
	5.420	5.417	5.415	5.412	5.410	5.407	5.405	5.402	5.400	5.397
86	.6482	.6479	.6476	.6473	.6470	.6467	.6464	.6461	.6458	.6455
	5.395	5.392	5.390	5.387	5.385	5.382	5.380	5.377	5.375	5.372
87	.6452	.6449	.6446	.6443	.6440	.6437	.6434	.6431	.6428	.6425
	5.370	5.367	5.365	5.362	5.360	5.357	5.355	5.352	5.350	5.347
88	.6422	.6419	.6416	.6413	.6410	.6407	.6404	.6401	.6399	.6396
	5.345	5.343	5.340	5.338	5.335	5.333	5.330	5.328	5.325	5.323
89	.6393	.6390	.6387	.6384	.6391	.6378	.6375	.6372	.6369	.6367
	5.320	5.318	5.316	5.313	5.311	5.308	5.306	5.304	5.301	5.299
90	.6364	.6361	.6358	.6355	.6352	.6349	.6346	.6343	.6341	.6338
	5.296	5.294	5.291	5.289	5.286	5.284	5.281	5.279	5.277	5.275
91	.6335	.6332	.6329	.6326	.6323	.6321	.6318	.6315	.6312	.6309
	5.272	5.270	5.267	5.265	5.263	5.261	5.258	5.256	5.253	5.251
92	.6306	.6303	.6301	.6298	.6295	.6292	.6289	.6286	.6284	.6281
	5.248	5.246	5.244	5.241	5.239	5.236	5.234	5.232	5.230	5.227
93	.6278	.6275	.6272	.6270	.6267	.6264	.6261	.6258	.6256	.6253
	5.225	5.222	5.220	5.218	5.216	5.213	5.210	5.208	5.206	5 204
94	.6250	.6247	.6244	.6242	.6239	.6236	.6233	.6231	.6228	.6225
	5.201	5.199	5.196	5.194	5.192	5.190	5.187	5.185	5.183	5.180
95	.6222	.6219	.6217	.6214	.6211	.6208	.6206	.6203	.6200	.6197
	5.178	5.176	5.174	5.171	5.169	5.166	5.164	5.162	5.160	5.157
96	.6195	.6192	.6189	.6186	.6184	.6181	.6178	.6176	.6173	.6170
	5.155	5.153	5.150	5.148	5.146	5.144	5.142	5.140	5.137	5.135

BAUME', SPECIFIC GRAVITY AND POUNDS PER GALLON—Con.

	0	1	2	3	4	5	6	7	8	9
97	.6167 5.132	.6165 5.130	.6162 5.128	.6159 5.126	.6157 5.124	.6154 5.121	.6151 5.119	.6148 5.116	.6146 5.114	.6143 5.112
98	.6140 5.110	.6138 5.108	.6135 5.106	.6132 5.103	.6130 5.101	.6127 5.099	.6124 5.096	.6122 5.094	.6119 5.092	.6116 5.090
99	.6114 5.088	.6111 5.085	.6108 5.083	.6106 5.081	.6103 5.079	.6100 5.076	.6098 5.074	.6095 5.072	.6092 5.070	.6090 5.068
100	.6087 5.066									

BAUME' SPECIFIC GRAVITY AND POUNDS PER GALLON.
(MODULUS 141.5 TAGLIABUE.)

	0	1	2	3	4	5	6	7	8	9
10	1.0000	.9993	.9986	.9979	.9972	.9965	.9958	.9951	.9944	.9937
	8.331	8.325	8.319	8.314	8.308	8.302	8.296	8.290	8.284	8.279
11	.9930	.9923	.9916	.9909	.9902	.9895	.9888	.9881	.9874	.9868
	8.273	8.267	8.261	8.255	8.249	8.244	8.238	8.232	8.226	8.221
12	.9861	.9854	.9847	.9840	.9833	.9826	.9820	.9813	.9806	.9799
	8.215	8.209	8.204	8.198	8.192	8.186	8.181	8.175	8.169	8.164
13	.9792	.9786	.9779	.9772	.9765	.9759	.9752	.9745	.9738	.9732
	8.158	8.153	8.147	8.141	8.135	8.130	8.124	8.119	8.113	8.108
14	.9725	.9718	.9712	.9705	.9698	.9692	.9685	.9679	.9672	.9665
	8.102	8.096	8.091	8.085	8.079	8.074	8.069	8.064	8.058	8.052
15	.9659	.9652	.9646	.9639	.9632	.9626	.9619	.9613	.9606	.9600
	8.047	8.041	8.036	.8030	8.024	8.019	8.014	8.009	8.003	7.998
16	.9593	.9587	.9580	.9574	.9567	.9561	.9554	.9548	.9542	.9535
	7.992	7.987	7.981	7.976	7.970	7.965	7.959	7.954	7.949	7.944
17	.9529	.9522	.9516	.9509	.9503	.9497	.9490	.9484	.9478	.9471
	7.939	7.933	7.928	7.922	7.917	7.912	7.906	7.901	7.896	7.890
18	.9465	.9459	.9452	.9446	.9440	.9433	.9427	.9421	.9415	.9408
	7.885	7.880	7.874	7.869	7.864	7.859	7.854	7.849	7.844	7.838
19	.9402	.9396	.9390	.9383	.9377	.9371	.9365	.9359	.9352	.9346
	7.833	7.828	7.823	7.817	7.812	7.807	7.802	7.797	7.791	7.786
20	.9340	.9334	.9328	.9322	.9315	.9309	.9303	.9297	.9291	.9285
	7.781	7.776	7.771	7.766	7.760	7.755	7.750	7.745	7.740	7.735
21	.9279	.9273	.9267	.9260	.9254	.9248	.9242	.9236	.9230	.9224
	7.730	7.725	7.720	7.715	7.710	7.705	7.700	7.695	7.690	7.685
22	.9218	.9212	.9206	.9200	.9194	.9188	.9182	.9176	.9170	.9165
	7.680	7.675	7.670	7.665	7.660	7.655	7.650	7.645	7.640	7.635
23	.9159	.9153	.9147	.9141	.9135	.9129	.9123	.9117	.9111	.9106
	7.630	7.625	7.620	7.615	7.610	7.605	7.600	7.595	7.590	7.586
24	.9100	.9094	.9088	.9082	.9076	.9071	.9065	.9059	.9053	.9047
	7.581	7.576	7.571	7.566	7.561	7.557	7.552	7.547	7.542	7.537
25	.9042	.9036	.9030	.9024	.9018	.9013	.9007	.9001	.8996	.8990
	7.533	7.528	7.523	7.518	7.513	7.509	7.504	7.499	7.495	[illegible]
26	.8984	.8978	.8973	.8967	.8961	.8956	.8950	.8944	.8939	[illegible]
	7.485	7.480	7.475	7.471	7.465	7.461	7.456	7.451	7.447	[illegible]
27	[illegible]	.8922	.8916	.8911	.8905	.8899	.8894	.8888	.8883	.8877
	7.437	7.433	7.428	7.424	7.419	7.414	7.410	7.405	7.400	7.395
28	.8871	.8866	.8860	.8855	.8849	.8844	.8838	.8833	.8827	.8822
	7.390	7.386	7.381	7.377	7.372	7.368	7.363	7.359	7.354	7.350
29	.8816	.8811	.8805	.8800	8794	.8789	.8783	.8778	.8772	.8767
	7.345	7.340	7.335	7.331	7.326	7.322	7.318	7.313	7.308	7.304
30	.8762	.8756	.8751	.8745	.8740	.8735	.8729	.8724	.8718	.8713
	7.300	7.295	7.290	7.285	7.281	7.277	7.272	7.268	7.263	7.259
31	.8708	.8702	.8697	.8692	.8686	.8681	.8676	.8670	.8665	.8660
	7.255	7.250	7.245	7.241	7.236	7.232	7.228	7.223	7.219	7.215
32	.8654	.8649	.8644	.8639	.8633	.8628	.8623	.8618	.8612	.8607
	7.210	7.205	7.201	7.197	7.192	7.188	7.184	7.180	7.175	7.170
33	.8602	.8597	.8591	.8586	.8581	.8576	.8571	.8565	.8560	.8555
	7.166	7.162	7.157	7.153	7.149	7.145	7.141	7.136	7.131	7.127
34	.8550	.8545	.8540	.8534	.8529	.8524	.8519	.8514	.8509	.8504
	7.123	7.119	7.115	7.110	7.106	7.101	7.097	7.093	7.089	7.085
35	.8498	.8493	.8488	.8483	.8478	.8473	.8468	.8463	.8458	.8453
	7.080	7.076	7.071	7.067	7.063	7.059	7.055	7.051	7.046	7.042
36	.8448	.8443	.8438	.8433	.8428	.8423	.8418	.8413	.8408	.8403
	7.038	7.034	7.030	7.026	7.021	7.017	7.013	7.009	7.005	7.001
37	.8398	.8393	.8388	.8383	.8378	.8373	.8368	.8363	.8358	.8353
	6.996	6.992	6.988	6.984	6.980	6.976	6.971	6.967	6.963	6.959
38	.8348	.8343	.8338	.8333	.8328	.8324	.8319	.8314	.8309	.8304
	6.955	6.951	6.946	6.942	6.938	6.935	6.931	6.926	6.922	6.918

BAUME' SPECIFIC GRAVITY AND POUNDS PER GALLON—Con.
(MODULUS 141.5)

	0	1	2	3	4	5	6	7	8	9
39	8299	.8294	.8289	.8285	.8280	.8275	.8270	.8265	.8260	.8256
	6.914	6.910	6.906	6.902	6.898	6.894	6.890	6.886	6.881	6.873
40	.8251	.8246	.8241	.8236	.8232	.8227	.8222	.8217	.8212	.8208
	6.874	6.870	6.866	6.861	6.858	6.854	.6850	6.846	6.841	6.838
41	.8203	.8198	.8193	.8189	.8184	.8179	.8174	.8170	.8165	.8160
	6.834	6.830	6.826	6.822	6.818	6.814	6.810	6.806	6.802	6 798
42	.8156	.8151	.8146	.8142	.8137	.8132	.8128	.8123	.8118	.8114
	6.795	6.791	6.786	6.783	6.779	6.775	6.771	6.767	6.763	6.760
43	.8109	.8104	.8100	.8095	.8090	.8086	.8081	.8076	.8072	.8067
	6.756	6.751	6.748	6.744	6.740	6.736	6.732	6.728	6.725	6.721
44	.8063	.8058	.8053	.8049	.8044	.8040	.8035	.8031	.8026	.8022
	6.717	6.713	6.709	6.706	6.701	6.698	6.694	6.691	6.868	6 683
45	.8017	.8012	.8008	.8003	.7999	.7994	.7990	7985	.7981	.7976
	6.679	6.675	6.671	6.667	6.664	6.660	6.656	6.652	6.649	6.645
46	.7972	.7967	.7963	.7958	.7954	.7949	.7945	.7941	.7936	.7932
	6.641	6.637	6.634	6.630	6.626	6.623	6.619	6.616	6.611	6.608
47	.7927	.7923	.7918	.7914	.7909	.7905	.7901	.7896	.7892	.7 87
	6.604	6.601	6.596	6.593	6.589	6.586	6.582	6.578	6.575	6.571
48	.7883	.7879	.7874	.7870	.7865	.7861	.7857	.7852	.7848	.7844
	6.567	6.564	6.560	6.556	6.552	6.549	6.546	6.542	6.538	6 535
49	.7839	.7835	.7831	.7826	.7822	.7818	.7813	.7809	.7805	.7800
	6.531	6.527	6.524	6.520	6.517	6.513	6.509	6.506	6.502	6.498
50	.7796	.7792	.7788	.7783	.7779	.7775	.7770	.7766	.7762	.7758
	6.495	6.492	6.488	6.484	6.481	6.477	6.473	6.470	6.467	6.463
51	.7753	.7749	.7745	.7741	.7736	.7732	.7728	.7724	.7720	.7715
	6.459	6.456	6.452	6.449	6.445	6.442	6.438	6.435	6.432	6.427
52	.7711	.7707	.7703	.7699	.7694	.7690	.7686	.7682	.7678	.7674
	6.424	6.421	6.417	6.414	6.410	6.407	6.403	6.400	6.397	6.393
53	.7669	.7665	.7661	.7657	.7653	.7649	.7645	.7640	.7636	.7632
	6.389	6.386	6.382	6.379	6.376	6.372	6.369	6.365	6 362	6.358
54	.7628	.7624	.7620	.7616	.7612	.7608	.7603	.7599	.7595	.7591
	6.355	6.352	6.348	6.345	6.342	6.338	6.334	6.331	6.327	6 324
55	.7587	.7583	.7579	.7575	.7571	.7567	.7563	.7559	.7555	.7551
	6.321	6.317	6.314	6.311	6.307	6.304	6.301	6.297	6.294	6 291
56	.7547	.7543	.7539	.7535	.7531	.7527	.7523	.7519	.7515	.7511
	6.287	6.284	6.281	6.277	6.274	6.271	6.267	6.264	6.261	6 257
57	.7507	.7503	.7499	.7495	.7491	.7487	.7483	.7479	.7475	.7471
	6.254	6.251	6.247	6.244	6.241	6.237	6 234	6.231	6.227	6.224
58	.7467	.7463	.7459	.7455	.7451	.7447	.7443	.7440	.7 36	.7432
	6.221	6.217	6.214	6.211	6.207	6.204	6.201	6.198	6.195	6.191
59	.7428	.7424	.7420	.7416	.7412	.7408	.7405	.7401	.7397	.7393
	6.188	6.185	6.182	6.178	6.175	6.172	6.169	6.166	6.162	6.159
60	.7389	.7385	.7381	.7377	.7374	.7370	.7366	.7362	.7358	.7354
	6.156	6.152	6.149	6.146	6.143	6.140	6.137	6.133	6.130	6.127
61	.7351	.7347	.7343	.7339	.7335	.7332	.7328	.7324	.7320	.7316
	6.124	6.121	6.117	6.114	6.111	6.108	6.105	6.102	6.098	6.095
62	.7313	.7309	.7305	.7301	.7298	.7294	.7290	.7286	.7283	.72 9
	6.092	6.089	6.086	6.082	6.080	6.077	6.073	6.070	6.067	6.064
63	.7275	.7271	.7268	.7264	.7260	.7256	.7253	.7249	.7245	.72 2
	6.061	6.057	6.055	6.052	6.048	6.045	6.042	6.039	6.036	6.033
64	.7238	.7234	.7230	.7227	.7223	.7219	.7216	.7212	.7208	.7205
	6.030	6.027	6.023	6.021	6.017	6.014	6.012	6.008	6.005	6.002
65	.7201	.7197	.7194	.7190	.7186	.7183	.7179	.7175	.7172	.7168
	5.999	5.996	5.993	5.990	5.987	5.984	5.981	5.977	5.975	5.972
66	.7165	.7161	.7157	.7154	.7150	.7146	.7143	.7139	.7136	.7132
	5.969	5.966	5.962	5.960	5.957	5.953	5.951	5.948	5.945	5.942
67	.7128	.7125	.7121	.7118	.7114	.7111	.7107	.7103	.7100	.7096
	5.938	5.936	5.933	5.930	5.927	5.924	5.921	5.918	5.915	5.9 2

BAUME' SPECIFIC GRAVITY AND POUNDS PER GALLON—Con.
(MODULUS 141.5)

	0	1	2	3	4	5	6	7	8	9
68	.7093	.7089	.7086	.7082	.7079	.7075	.7071	.7068	.7064	.7061
	5.909	5.906	5.903	5.900	5.898	5.894	5.891	5.888	5.885	5.883
69	.7057	.7054	.7050	.7047	.7043	.7040	.7036	.7033	.7029	.7026
	5.879	5.877	5.873	5.871	5.868	5.865	5.862	5.859	5.856	5.853
70	.7022	.7019	.7015	.7012	.7008	.7005	.7001	.6998	.6995	.6991
	5.850	5.848	5.844	5.842	5.838	5.836	5.833	5.830	5.828	5.82[illegible]
71	.6988	.6984	.6981	.6977	.6974	.6970	.6967	.6964	.6960	.6957
	5.822	5.818	5.816	5.813	5.810	5.807	5.804	5.802	5.798	5.796
72	.6953	.6950	.6946	.6943	.6940	.6936	.6933	.6929	.6926	.6923
	5.793	5.790	5.787	5.784	5.782	5.778	.5776	5.773	5.770	5.768
73	.6919	.6916	.6912	.6909	.6906	.6902	.6899	.6896	.6892	.6889
	5.764	5.762	5.758	5.756	5.753	5.750	5.748	5.745	5.742	5.739
74	.6886	.6882	.6879	.6876	.6872	.6869	.6866	.6862	.6859	.6856
	5.737	5.733	5.731	5.728	5.725	5.723	5.720	5.717	5.714	5.712
75	.6852	.6849	.6846	.6842	.6839	.6836	.6832	.6829	.6826	.6823
	5.708	5.706	5.703	5.700	5.698	5.695	5.6[illegible]2	5.689	5.687	5.684
76	.6819	.6816	.6813	.6809	.6806	.6803	.6800	.6796	.6793	.67[illegible]0
	5.681	5.678	5.676	5.673	5.670	5.668	5.665	5.662	5.659	5.657
77	.6787	.6783	.6780	.6777	.6774	.6770	.6767	.6764	.6761	.6757
	5.654	5.651	5.648	5.646	5.643	5.640	5 638	5.635	5.633	5.629
78	.6754	.6751	.6748	.6745	.6741	.6738	.6735	.6732	.6728	.6725
	5.627	5.624	5.622	5.619	5.616	5.613	5.611	5.608	5.605	5.603
79	.6722	.6719	.6716	.6713	.6709	.6706	.6703	.6700	.66[illegible]7	.66[illegible]3
	5.600	5.597	5.595	5.593	5.589	5.587	5.584	5.582	5.579	5.576
80	.6690	.6687	.6684	.6681	.6678	.6675	.6671	.6668	.6665	.66[illegible]2
	5.573	5.571	5.568	5.566	5.563	5.561	5.558	5.555	5.553	5 550
81	.6659	.6656	.6653	.6649	.6646	.6643	.6640	.6637	.6634	.6631
	5.5 8	5.545	5.543	5.540	5.537	5.534	5.532	5.529	5.527	5.524
82	.6628	.6625	.6621	.6618	.6615	.6612	.6609	.6606	.6603	.6600
	5.522	5.519	5.516	5.513	5.511	5.508	5.506	5.503	5.501	5.498
83	.6597	.6594	.6591	.6588	.6584	.6581	.6578	.6575	.6572	.656[illegible]
	5.496	5.493	5.491	5.488	5.485	5.483	5.480	5.478	5.475	5.473
84	.6566	.6563	.6560	.6557	.6554	.6551	.6548	.6545	.6542	.6539
	5.470	5.468	5.465	5.463	5.460	5.458	5.455	5.453	5.450	5.448
85	.6536	.6533	.6530	.6527	.6524	.6521	.6518	.6515	.6512	.6509
	5.445	5.443	5.440	5.438	5.435	5.433	5.430	5.428	5.425	5.423
86	.6506	.6503	.6500	.6497	.6494	.6491	.6488	.6485	.6482	.6479
	5.420	5.418	5.415	5.413	5.410	5.408	5.405	5.403	5.400	5.3[illegible]8
87	.6476	.6473	.6470	.6467	.6464	.6461	.6458	.6455	.6452	.6449
	5.395	5.393	5.390	5.388	5.385	5.383	5.380	5.378	5.375	5.373
88	.6446	.6444	.6441	.6438	.6435	.6432	.6429	.6426	.6423	.6420
	5.370	5.368	5.366	5.363	5.361	5.358	5.356	5.353	5.351	5.349
89	.6417	.6414	.6411	.6409	.6406	.6403	.6400	.6397	.6394	.6391
	5.346	5.344	5.341	5.339	5.337	5.334	5.332	5.329	5.327	5.324
90	.6388	.6385	.6382	.6380	6377	.6374	.6371	.6368	.6365	.6362
	5.322	5.319	5.317	5.315	5.313	5.310	5.308	5 305	5.303	5.300
91	.6360	.6357	.6354	.6351	.6348	.6345	.6342	.6340	.6337	.6334
	5.299	5.296	5.294	5.291	5.289	5.286	5.284	5.282	5.279	5.277
92	.6331	.6328	.6325	.6323	.6320	.6317	.6314	.6311	.6309	.6306
	5 274	5.272	5.269	5.268	5.265	5.263	5.260	5.258	5.256	5.254
93	.6303	.6300	.6297	.6294	.6292	.6289	.6286	.6283	.6281	.6278
	5.251	5.249	5.246	5.244	5.242	5.239	5.237	5.234	5.233	5.230
94	.6275	.6272	.6269	.6267	.6264	.6261	.6258	.6256	.6253	.6250
	5.228	5.225	5.223	5.221	5.219	5.216	5.214	5.212	5.209	5.207
95	.6247	.6244	.6242	.6239	.6236	.6233	.6231	.6228	.6225	.6223
	5.204	5.202	5.200	5.198	5.195	5.193	5.191	5.189	5.186	5.184
96	.6220	.6217	.6214	.6212	.6209	.6206	.6203	.6201	.6198	.6195
	5.182	5.179	5.177	5.175	5.173	5.170	5.168	5.166	5.164	5.161

BAUME' SPECIFIC GRAVITY AND POUNDS PER GALLON—Con.
(MODULUS 141.5)

	0	1	2	3	4	5	6	7	8	9
97	.6193	.6190	.6187	.6184	.6182	.6179	.6176	.6174	.6171	.6168
	5.159	5.157	5.154	5.152	5.150	5.148	5.145	5.144	5.141	5.139
98	.6166	.6163	.6160	.6158	.6155	.6152	.6150	.6147	.6144	.6141
	5.137	5.134	5.132	5.130	5.128	5.125	5.124	5.121	5.119	5.116
99	.6139	.6136	.6134	.6131	.6128	.6126	.6123	.6120	.6118	.6115
	5.114	5.112	5.110	5.108	5.105	5.104	5.101	5.099	5.097	5.094

Specific Gravity Tables for Petroleum Oils

(General considerations, Bureau of Standards.)

(a) **The Baume Scale,** for liquids lighter than water is based upon the following relation to specific gravity:

$$\text{Degrees Baume'} = \frac{140}{\text{Sp. gr. } 60°/60°\text{F}} - 130$$

or

$$\text{Sp. gr. } 60°/60° = \frac{140}{130 + \text{deg.B.}}$$

(b) **Specific Gravity,** as used in these tables is defined as the ratio of the weight (in vacuo) of equal volumes of oil and of water at 60°F—that is, the true and not the apparent specific gravity is employed throughout the tables.

(c) The weight per gallon of oil is the apparent weight of a volume of 231 cubic inches of oil at 60°F when weighed in air of 50% humidity, at the same temperature as the oil, and at a presure of 760 mm. of mercury. The weighing is also assumed to be made against brass weights of 8.4 density or against weights reduced to that basis.

(d) The weight of a gallon of water at 60°F is as follows: In air, 8.32823 pounds; in vacuo, 8.33722 pounds.

On account of the way specific gravity is defined, it is necessary to apply a buoyancy correction to the product of the specific gravity of the oil and the weight of a gallon of water in order to obtain the apparent weight of a gallon of oil in air at 60°F.

The tables that follow apply to all petroleum oils, both crude and refined, produced in the United States. Each grade of oil, gasoline, illuminating oil, lubricating and fuel oil, etc., falls into its proper place in the tables by reason of its specific gravity.

Although it is generally believed that California oils have a considerably higher rate of expansion than do oils from the Central and Eastern States, this has not been found to be the case, and the slightly higher rate is not sufficient to cause an appreciable error in results carried only to the degree of accuracy here given.

Another commonly used Gravity Scale is that of the Petroleum Association (S. V.) used on instruments made by the C. J. Tagliabue Instrument Company based upon the following formula.

$$\text{Specific Gravity } 60°/60° = \frac{141.5}{131.5 + \text{degrees Baume'}}$$

Reduction of Specific Gravity Readings to 60°F.

(This table shows the specific gravities at 60°/60° F of oils having, at the designated temperatures, the observed specific gravities indicated. For example, if the observed specific gravity is 0.610 at 80°F, the true specific gravity at 60°/60°F will be 0.621. The headings "Observed specific gravity" and "Observed temperature" signify the true indication of the hydrometer and the true temperature of the oil; that is, the observed readings corrected, if necessary, for instrumental errors.)

Observed temperature in °F	Observed specific gravities									
	0.610	0.611	0.612	0.613	0.614	.615	0.616	0.617	0.618	0.619
	Corresponding specific gravities at 60°/60° F									
62	....	....	....	....	....	....	....	....	....	0.6200
64	....	....	....	....	....	....	....	....	0.6200	.6210
66	....	....	....	....	....	....	....	0.6200	.6210	.6220
68	....	....	....	....	....	0.6200	.6205	.6215	.6225	.6235
70	....	....	....	....	0.6200	.6210	.6215	.6225	.6235	.6245
72	....	....	....	0.6200	.6210	.6220	.6225	.6235	.6245	.6255
74	....	....	0.6200	.6210	.6220	.6230	.6235	.6245	.6255	.6265
76	....	0.6200	.6210	.6220	.6230	.6240	.6245	.6255	.6265	.6275
78	0.6200	.6210	.6220	.6230	.6240	.6250	.6255	.6265	.6275	.6285
80	.621	.622	.623	.624	.625	.626	.626	.627	.628	.629
82	.622	.623	.624	.625	.626	.627	.628	.629	.630	.631
84	.623	.624	.625	.626	.627	.628	.629	.630	.631	.632
86	.624	.625	.626	.627	.628	.629	.630	.631	.632	.633
88	.625	.626	.627	.628	.629	.630	.631	.632	.633	.634
90	626	.627	.628	.629	.630	.631	.632	.633	.634	.635
92	.627	.628	.629	.630	.631	.632	.633	.634	.635	.636
94	.628	.629	.630	.631	.632	.633	.634	.635	.636	.637
96	.629	.630	.631	.632	.633	.634	.635	.636	.637	.638
98	.630	.631	.632	.633	.634	.635	.636	.637	.638	.639
100	.631	.632	.633	.634	.635	.636	.637	.638	.639	.640
102	.632	.633	.634	.635	.636	.637	.638	.639	.640	.641
104	.633	.634	.635	.636	.637	.638	.639	.640	.641	.642
106	.634	.635	.636	.637	.638	.639	.640	.641	.642	.643
108	.635	.636	.637	.638	.639	.640	.641	.642	.643	.644
110	.636	.637	.638	.639	.640	.641	.642	.643	.644	.645
112	.637	.638	.639	.640	.641	.642	.643	.644	.645	.646
114	.638	.639	.640	.641	.642	.643	.644	.645	.646	.647
116	.639	.640	.641	.642	.643	.644	.645	.646	.647	.648
118	.640	.641	.642	.643	.644	.645	.646	.647	.648	.649
120	.641	.642	.643	.644	.645	.646	.647	.648	.649	.650

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.630	0.631	0.632	0.633	0.634	0.635	0.636	0.637	0.638	0.639
	Corresponding specific gravities at 60°/60° F									
30	....	....	....	....	....	....	0.620	0.621	0.622	0.623
32	....	....	....	....	....	0.620	.621	.622	.623	.624
34	....	....	....	....	0.620	.621	.622	.623	.624	.625
36	....	....	....	0.620	.621	.622	.623	.624	.625	.626
38	....	....	0.620	.621	.622	.623	.624	.625	.626	.627
40	....	0.6200	.6210	.6220	.6230	.6240	.6255	.6265	.6275	.6285
42	0.6200	.6210	.6220	.6230	.6240	.6250	.6265	.6275	.6285	.6295
44	.6210	.6220	.6230	.6240	.6250	.6260	.6275	.6285	.6295	.6305
46	.6220	.6230	.6240	.6250	.6260	.6270	.6285	.6295	.6305	.6315
48	.6230	.6240	.6250	.6260	.6270	.6280	.6295	.6305	.6315	.6325
50	.6245	.6255	.6265	.6275	.6285	.6295	.6305	.6315	.6325	.6335
52	.6260	.6270	.6280	.6290	.6300	.6310	.6320	.6330	.6340	.6350
54	.6270	.6280	.6290	.6300	.6310	.6320	.6330	.6340	.6350	.6360
56	.6280	.6290	.6300	.6310	.6320	.6330	.6340	.6350	.6360	.6370
58	.6290	.6300	.6310	.6320	.6330	.6340	.6350	.6360	.6370	.6380
60	.6300	.6310	.6320	.6330	.6340	.6350	.6360	.6370	.6380	.6390
62	.6310	.6320	.6330	.6340	.6350	.6360	.6370	.6380	.6390	.6400
64	.6320	.6330	.6340	.6350	.6360	.6370	.6380	.6390	.6400	.6410
66	.6330	.6340	.6350	.6360	.6370	.6380	.6390	.6400	.6410	.6420
68	.6345	.6355	.6365	.6375	.6385	.6395	.6400	.6410	.6420	.6430
70	.6355	.6365	.6375	.6385	.6395	.6405	.6410	.6420	.6430	.6440
72	.6365	.6375	.6385	.6395	.6405	.6415	.6420	.6430	.6440	.6450
74	.6375	.6385	.6395	.6405	.6415	.6425	.6430	.6440	.6450	.6460
76	.6385	.6395	.6405	.6415	.6425	.6435	.6440	.6450	.6460	.6470
78	.6395	.6405	.6415	.6425	.6435	.6445	.6450	.6460	.6470	.6480
80	.640	.641	.642	.643	.644	.645	.646	.647	.648	.649
82	.641	.642	.643	.644	.645	.646	.647	.648	.649	.650
84	.642	.643	.644	.645	.646	.647	.648	.649	.650	.651
86	.643	.644	.645	.646	.647	.648	.649	.650	.651	.652
88	.644	.645	.646	.647	.648	.649	.650	.651	.652	.653
90	.645	.646	.647	.648	.649	.650	.651	.652	.653	.654
92	.646	.647	.648	.649	.650	.651	.652	.653	.654	.655
94	.647	.648	.649	.650	.651	.652	.653	.654	.655	.656
96	.648	.649	.650	.651	.652	.653	.654	.655	.656	.657
98	.649	.650	.651	.652	.653	.654	.655	.656	.657	.658
100	.650	.651	.652	.653	.654	.655	.656	.657	.658	.659
102	.651	.652	.653	.654	.655	.656	.657	.658	.659	.660
104	.652	.653	.654	.655	.656	.657	.658	.659	.660	.661
106	.653	.654	.655	.656	.657	.658	.659	.660	.661	.662
108	.654	.655	.656	.657	.658	.659	.660	.661	.662	.663
110	.655	.656	.657	.658	.659	.660	.661	.662	.663	.664
112	.656	.657	.658	.659	.660	.661	.662	.663	.664	.665
114	.657	.658	.659	.660	.661	.662	.663	.664	.665	.666
116	.658	.659	.660	.661	.662	.663	.664	.665	.666	.667
118	.659	.660	.661	.662	.663	.664	.665	.666	.667	.668
120	.660	.661	.662	.663	.664	.665	.666	.667	.668	.669

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.620	0.621	0.622	0.623	0.624	0.625	0.626	0.627	0.628	0.629
	Corresponding specific gravities at 60°/60° F									
44	....	....	....	....	....	....	....	....	....	0.6200
46	....	....	....	....	....	....	....	....	0.6200	.6210
48	....	....	....	....	....	....	....	0.6200	.6210	.6220
50	....	....	....	....	....	0.6200	0.6205	.6215	.6225	.6235
52	....	....	....	....	0.6200	.6210	.6220	.6230	.6240	.6250
54	....	....	....	0.6200	.6210	.6220	.6230	.6240	.6250	.6260
56	....	....	0.6200	.6210	.6220	.6230	.6240	.6250	.6260	.6270
58	....	0.6200	.6210	.6220	.6230	.6240	.6250	.6260	.6270	.6280
60	0.6200	.6210	.6220	.6230	.6240	.6250	.6260	.6270	.6280	.6290
62	.6210	.6220	.6230	.6240	.6250	.6260	.6270	.6280	.6290	.6300
64	.6220	.6230	.6240	.6250	.6260	.6270	.6280	.6290	.6300	.6310
66	.6230	.6240	.6250	.6260	.6270	.6280	.6290	.6300	.6310	.6320
68	.6245	.6255	.6265	.6275	.6285	.6295	.6305	.6315	.6325	.6335
70	.6255	.6265	.6275	.6285	.6295	.6305	.6315	.6325	.6335	.6345
72	.6265	.6275	.6285	.6295	.6305	.6315	.6325	.6335	.6345	.6355
74	.6275	.6285	.6295	.6305	.6315	.6325	.6335	.6345	.6355	.6365
76	.6285	.6295	.6305	.6315	.6325	.6335	.6345	.6355	.6365	.6375
78	.6295	6305	.6315	.6325	.6335	.6345	.6355	.6365	.6375	.6385
80	.630	.631	.632	.633	.634	.635	.636	.637	.638	.639
82	.632	.633	.634	.635	.636	.637	.637	.638	.639	.640
84	.633	.634	.635	.636	.637	.638	.638	.639	.640	.641
86	.634	.635	.636	.637	.638	.639	.639	.640	.641	.642
88	.635	.636	.637	.638	.639	.640	.640	.641	.642	.643
90	.636	.637	.638	.639	.640	.641	.641	.642	.643	.644
92	.637	.638	.639	.640	.641	.642	.642	.643	.644	.645
94	.638	.639	.640	641	.642	.643	.643	.644	.645	.646
96	.639	.640	.641	.642	.643	.644	.644	.645	.646	.647
98	.640	.641	.642	.643	.644	.645	.645	.646	.647	.648
100	.641	.642	.643	.644	.645	.646	.646	647	.648	.649
102	.642	.643	.644	.645	.646	.647	.647	.648	.649	.650
104	.643	.644	.645	.646	.647	.648	.648	.649	.650	.651
106	.644	.645	.646	.647	.648	.649	.649	.650	.651	.652
108	645	.646	.647	.648	649	.650	.650	.651	.652	.653
110	.646	.647	.648	.649	.650	.651	.651	.552	.653	.654
112	.647	.648	.649	.650	.651	.652	.652	.653	.654	.655
114	.648	.649	.650	.651	.652	.653	.653	.654	.655	.656
116	.649	.650	.651	.652	.653	.654	.654	.655	.656	.657
118	650	.651	.652	653	.654	.655	.655	.656	.657	.658
120	.651	.652	.653	654	.655	.656	.656	.657	.658	.659

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.640	0.641	0.642	0.643	0.644	0.645	0.646	0.647	0.648	0.649
	Corresponding specific gravities at 60°/60° F									
30	0.624	0.625	0.626	0.627	0.628	0.629	0.630	0.631	0.632	0.633
32	.625	.626	.627	.628	.629	.630	.631	.632	.633	.634
34	.626	.627	.628	.629	.630	.631	.632	.633	.634	.635
36	.627	.628	.629	.630	.631	.632	.633	.634	.635	.636
38	.628	.629	.630	.631	.632	.633	.634	.635	.636	.637
40	.6295	.6305	.6315	.6325	.6335	.6345	.6355	.6365	.6375	.6385
42	.6305	.6315	.6325	.6335	.6345	.6355	.6365	.6375	.6385	.6395
44	6315	.6325	.6335	.6345	.6355	.6365	.6375	.6385	.6395	.6405
46	.6325	.6335	.6345	.6355	.6365	.6375	.6385	.6395	.6405	.6415
48	.6335	.6345	.6355	.6365	.6375	.6385	.6395	.6405	.6415	.6425
50	.6345	.6355	.6365	.6375	.6385	.6395	.6410	.6420	.6430	.6440
52	.6360	.6370	.6380	.6390	.6400	.6410	.6420	.6430	.6440	.6450
54	.6370	.6380	.6390	.6400	.6410	.6420	.6430	.6440	.6450	.6460
56	.6380	.6390	.6400	.6410	.6420	.6430	.6440	.6450	.6460	.6470
58	.6390	.6400	.6410	.6420	.6430	.6440	.6450	.6460	.6470	.6480
60	.6400	.6410	.6420	.6430	.6440	.6450	.6460	.6470	.6480	.6490
62	.6410	.6420	.6430	.6440	.6450	.6460	.6470	.6480	.6490	.6500
64	.6420	.6430	.6440	.6450	.6460	.6470	.6480	.6490	.6500	.6510
66	.6430	.6440	.6450	.6460	.6470	.6480	.6490	.6500	.6510	.6520
68	.6440	.6450	.6460	.6470	.6480	.6490	.6500	.6510	.6520	.6530
70	.6450	.6460	.6470	.6480	.6490	.6500	.6510	.6520	.6530	.6540
72	.6460	.6470	.6480	.6490	.6500	.6510	.6520	.6530	.6540	.6550
74	.6470	.6480	.6490	.6500	.6510	.6520	.6530	.6540	.6550	.6560
76	.6480	.6490	.6500	.6510	.6520	.6530	.6540	.6550	.6560	.6570
78	.6490	.6500	.6510	.6520	.6530	.6540	.6550	.6560	.6570	.6580
80	.650	.651	.652	.653	.654	.655	.656	.657	.658	.659
82	.651	.652	.653	.654	.655	.656	.657	.658	.659	.660
84	.652	.653	.654	.655	.656	.657	.658	.659	.660	.661
86	.653	.654	.655	.656	.657	.658	.659	.660	.661	.662
88	.654	.655	.656	.657	.658	.659	.660	.661	.662	.663
90	.655	.656	.657	.658	.659	.660	.661	.662	.663	.664
92	.656	.657	.658	.659	.660	.661	.662	.663	.664	.665
94	.657	.658	.659	.660	.661	.662	.663	.664	.665	.666
96	.658	.659	.660	.661	.662	.663	.664	.665	.666	.667
98	.659	.660	.661	.662	.663	.664	.665	.666	.667	.668
100	.660	.661	.662	.663	.664	.665	.666	.667	.668	.669
102	.661	.662	.663	.664	.665	.666	.667	.668	.669	.670
104	.662	.663	.664	.665	.666	.667	.668	.669	.670	.671
106	.663	.664	.665	.666	.667	.668	.669	.670	.671	.672
108	.664	.665	.666	.667	.668	.669	.670	.671	.672	.673
110	.665	.666	.667	.668	.669	.670	.671	.672	.673	.674
112	.666	.667	.668	.669	.670	.671	.672	.673	.674	.675
114	.667	.668	.669	.670	.671	.672	.673	.674	.675	.676
116	.668	.669	.670	.671	.672	.673	.674	.675	.676	.677
118	.669	.670	.671	.672	.673	.674	.675	.676	.677	.678
120	.670	.671	.672	.673	.674	.675	.676	.677	.678	.679

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.650	0.651	0.652	0.653	0.654	0.655	0.656	0.657	0.658	0.659
	Corresponding specific gravities at 60°/60° F									
30	0.634	0.635	0.636	0.637	0.638	0.639	0.640	0.641	0.642	0.643
32	.635	.636	.637	.638	.639	.640	.641	.642	.643	.644
34	.636	.637	.638	.639	.640	.641	.642	.643	.644	.645
36	.637	.638	.639	.640	.641	.642	.643	.644	.645	.646
38	.638	.639	.640	.641	.642	.643	.644	.645	.646	.647
40	.6395	.6405	.6415	.6425	.6435	.6445	.6455	.6465	.6475	.6485
42	.6405	.6415	.6425	.6435	.6445	.6455	.6465	.6475	.6485	.6495
44	.6415	.6425	.6435	.6445	.6455	.6465	.6475	.6485	.6495	.6505
46	.6425	.6435	.6445	.6455	.6465	.6475	.6485	.6495	.6505	.6515
48	.6435	.6445	.6455	.6465	.6475	.6485	.6495	.6505	.6515	.6525
50	.6450	.6460	.6470	.6480	.6490	.6500	.6510	.6520	.6530	.6540
52	.6460	.6470	.6480	.6490	.6500	.6510	.6520	.6530	.6540	.6550
54	.6470	.6480	.6490	.6500	.6510	.6520	.6530	.6540	.6550	.6560
56	.6480	.6490	.6500	.6510	.6520	.6530	.6540	.6550	.6560	.6570
58	.6490	.6500	.6510	.6520	.6530	.6540	.6550	.6560	.6570	.6580
60	.6500	.6510	.6520	.6530	.6540	.6550	.6560	.6570	.6580	.6590
62	.6510	.6520	.6530	.6540	.6550	.6560	.6570	.6580	.6590	.6600
64	.6520	.6530	.6540	.6550	.6560	.6570	.6580	.6590	.6600	.6610
66	.6530	.6540	.6550	.6560	.6570	.6580	.6590	.6600	.6610	.6620
68	.6540	.6550	.6560	.6570	.6580	.6590	.6600	.6610	.6620	.6630
70	.6550	.6560	.6570	.6580	.6590	.6600	.6610	.6620	.6630	.6640
72	.6560	.6570	.6580	.6590	.6600	.6610	.6620	.6630	.6640	.6650
74	.6570	.6580	.6590	.6600	.6610	.6620	.6630	.6640	.6650	.6660
76	.6580	.6590	.6600	.6610	.6620	.6630	.6640	.6650	.6660	.6670
78	.6590	.6600	.6610	.6620	.6630	.6640	.6650	.6660	.6670	.6680
80	.660	.661	.662	.663	.664	.665	.666	.667	.668	.669
82	.661	.662	.663	.664	.665	.666	.667	.668	.669	.670
84	.662	.663	.664	.665	.666	.667	.668	.669	.670	.671
86	.663	.664	.665	.666	.667	.668	.669	.670	.671	.672
88	.664	.665	.666	.667	.668	.669	.670	.671	.672	.673
90	.665	.666	.667	.668	.669	.670	.671	.672	.673	.674
92	.666	.667	.668	.669	.670	.671	.672	.673	.674	.675
94	.667	.668	.669	.670	.671	.672	.673	.674	.675	.676
96	.668	.669	.670	.671	.672	.673	.674	.675	.676	.677
98	.669	.670	.671	.672	.673	.674	.675	.676	.677	.678
100	.670	.671	.672	.673	.674	.675	.676	.677	.678	.679
102	.671	.672	.673	.674	.675	.676	.677	.678	.679	.680
104	.672	.673	.674	.674	.676	.677	.678	.679	.680	.681
106	.673	.674	.675	.676	.677	.678	.679	.680	.681	.682
108	.674	.675	.676	.677	.678	.679	.679	.680	.681	.682
110	.675	.676	.677	.678	.679	.680	.680	.681	.682	.683
112	.676	.677	.678	.679	.680	.681	.681	.682	.683	.684
114	.677	.678	.679	.680	.681	.682	.682	.683	.684	.685
116	.678	.679	.680	.681	.682	.683	.683	.684	.685	.686
118	.679	.680	.681	.682	.683	.684	.684	.685	.686	.687
120	680	.681	.682	.683	.684	.685	.685	.686	.687	.688

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.660	0.661	0.662	0.663	0.664	0.665	0.666	0.667	0.668	0.669
	Corresponding specific gravities at 60°/60° F									
30	0.664	0.645	0.646	0.647	0.648	0.649	0.650	0.651	0.652	0.653
32	.645	.646	.647	.648	.649	.650	.651	.652	653	.654
34	.646	.647	.648	.649	.650	.651	.652	.653	.654	.655
36	.647	.648	.649	.650	.651	.652	.653	.654	.655	.656
38	.648	.649	.650	.651	.652	.653	.655	.656	.657	.658
40	.6495	.6505	.6515	.6525	.6535	.6545	.6560	.6570	.6580	.6590
42	.6505	.6515	.6525	.6535	.6545	.6555	.6570	.6580	.6590	.6600
44	.6515	.6525	.6535	.6545	.6555	.6565	.6580	.6590	.6600	.6610
46	.6525	.6535	.6545	.6555	.6565	.6575	.6590	.6600	.6610	.6620
48	.6535	.6545	.6555	.6565	.6575	.6585	.6600	.6610	.6620	.6630
50	.6550	.6560	.6570	.6580	.6590	.6600	.6610	.6620	.6630	.6640
52	.6560	.6570	.6580	.6590	.6600	.6610	.6620	.6630	.6640	.6650
54	.6570	.6580	.6590	.6600	.6610	.6620	.6630	.6640	.6650	.6660
56	.6580	.6590	.6600	.6610	.6620	.6630	.6640	.6650	.6660	.6670
58	.6590	.6600	.6610	.6620	.6630	.6640	.6650	.6660	.6670	.6680
60	.6600	.6610	.6620	.6630	.6640	.6650	.6660	.6670	.6680	.6690
62	.6610	.6620	.6630	.6640	.6650	.6660	.6670	.6680	.6690	.6700
64	.6620	.6630	.6640	.6650	.6660	.6670	.6680	.6690	.6700	.6710
66	.6630	.6640	.6650	.6660	.6670	.6680	.6690	.6700	.6710	.6720
68	.6640	.6650	.6660	.6670	.6680	.6690	.6700	.6710	.6720	.6730
70	.6650	.6660	.6670	.6680	.6690	.6700	.6710	.6720	.6730	.6740
72	.6660	.6670	.6680	.6690	.6700	.6710	.6720	.6730	.6740	.6750
74	.6670	.6680	.6690	.6700	.6710	.6720	.6730	.6740	.6750	.6760
76	.6680	.6690	.6700	.6710	.6720	.6730	.6740	.6750	.6760	.6770
78	.6690	.6700	.6710	.6720	.6730	.6740	.6750	.6760	.6770	.6780
80	.670	.671	.672	.673	.674	.675	.676	677	.678	.679
82	.671	.672	.673	.674	.675	.676	.677	.678	.679	.680
84	.672	.673	.674	.675	.676	.677	.678	.679	.680	.681
86	.673	.674	.675	.676	.677	.678	.679	.680	.681	.682
88	.674	.675	.676	.677	.678	.679	.679	.680	.681	.682
90	.675	.676	.677	.678	.679	.680	.680	.681	.682	.683
92	.676	.677	.678	.679	.680	.681	.681	.682	.683	.684
94	.677	.678	.679	.680	.681	.682	.682	.683	.684	.685
96	.678	.679	.680	.681	.682	.683	.683	.684	.685	.686
98	.679	.680	.681	.682	.683	.684	.684	.685	.686	.687
100	.680	.681	.682	.683	.684	.685	.685	.686	.687	.688
102	.681	.682	.683	.684	.685	.686	.686	.687	.688	.689
104	.682	.683	.684	.685	.686	.687	.687	.688	.689	.690
106	.683	.684	.685	.686	.687	.688	.688	.689	.690	.691
108	.683	.684	.685	.686	.687	.688	.689	.690	.691	.692
110	.684	.685	.686	.687	.688	.689	.690	.691	.692	.693
112	.685	.686	.687	.688	.689	.690	.691	.692	.693	.694
114	.686	.687	.688	.689	.690	.691	.692	.693	.694	.695
116	.687	.688	.689	.690	.691	.692	.693	.694	.695	.696
118	.688	.689	.690	.691	.692	.693	.694	.695	.696	.697
120	.689	.690	.691	.692	.693	.694	.695	.696	.697	.698

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.670	0.671	0.672	0.673	0.674	0.675	0.676	0.677	0.678	0.679
	Corresponding specific gravities at 60°/60° F									
30	0.654	0.655	0.656	0.657	0.658	0.659	0.661	0.662	0.663	0.664
32	.655	.656	.657	.658	.659	.660	.662	.663	.664	.665
34	.656	.657	.658	.659	.660	.661	.663	.664	.665	.666
36	.657	.658	.659	.660	.661	.662	.664	.665	.666	.667
38	.659	.660	.661	.662	.663	.664	.665	.666	.667	.668
40	.6600	.6610	.6620	.6630	.6640	.6650	.6660	.6670	.6680	.6690
42	.6610	.6620	.6630	.6640	.6650	.6660	.6670	.6680	.6690	.6700
44	.6620	.6630	.6640	.6650	.6660	.6670	.6680	.6690	.6700	.6710
46	.6630	.6640	.6650	.6660	.6670	.6680	.6690	.6700	.6710	.6720
48	.6640	.6650	.6660	.6670	.6680	.6690	.6700	.6710	.6720	.6730
50	.6650	.6660	.6670	.6680	.6690	.6700	.6710	.6720	.6730	.6740
52	.6660	.6670	.6680	.6690	.6700	.6710	.6720	.6730	.6740	.6750
54	.6670	.6680	.6690	.6700	.6710	.6720	.6730	.6740	.6750	.6760
56	.6680	6690	.6700	.6710	.6720	.6730	.6740	.6750	.6760	.6770
58	.6690	.6700	.6710	.6720	.6730	.6740	.6750	.6760	.6770	.6780
60	.6700	.6710	.6720	.6730	.6740	.6750	.6760	.6770	.6780	.6790
62	.6710	.6720	.6730	.6740	6750	.6760	.6770	.6780	.6790	.6800
64	.6720	.6730	.6740	.6750	.6760	.6770	.6780	.6790	.6800	.6810
66	.6730	.6740	.6750	.6760	.6770	.6780	.6790	.6800	.6810	.6820
68	.6740	.6750	.6760	.6770	.6780	.6790	.6800	.6810	.6820	.6830
70	.6750	.6760	.6770	.6780	.6790	.6800	.6810	.6820	.6830	.6840
72	.6760	.6770	.6780	.6790	.6800	.6810	.6820	.6830	.6840	.6850
74	.6770	.6780	.6790	.6800	.6810	.6820	.6830	.6840	.6850	.6860
76	.6780	.6790	.6800	.6810	.6820	.6830	.6835	.6845	.6855	.6865
78	.6790	.6800	.6810	.6820	.6830	.6840	.6845	.6855	.6865	.6875
80	.680	.681	.682	.683	.684	.685	.685	.686	.687	.688
82	.681	.682	.683	.684	.685	.686	.686	.687	.688	.689
84	.682	.683	.684	.685	.686	.687	.687	.688	.689	.690
86	.683	.684	.685	.686	.687	.688	.688	.689	.690	.691
88	.683	.684	.685	.686	.687	.688	.689	.690	.691	.692
90	.684	.685	.686	.687	.688	.689	.690	.691	.692	.693
92	.685	.686	.687	.688	.689	.690	.691	.692	.693	.694
94	.686	.687	.688	.689	.690	.691	.692	.693	.694	.695
96	.687	.688	.689	690	.691	.692	.693	.694	.695	.696
98	.688	.689	.690	.691	.692	.693	.694	.695	.696	.697
100	.689	.690	.691	.692	.693	.694	.695	.696	.697	.698
102	.690	.691	.692	.693	.694	.695	.696	.697	.698	.699
104	691	.692	.693	.694	.695	.696	.697	.698	.699	.700
106	.692	.693	.694	.695	.696	.697	.698	.699	.700	.701
108	.693	.694	.695	.696	.697	.698	.699	.700	.701	.702
110	.694	.695	.696	.697	.698	.699	.700	.701	.702	.703
112	.695	.696	.697	.698	.699	.700	.701	.702	.703	.704
114	.696	.697	.698	.699	700	.701	.702	.703	.704	.705
116	.697	.698	699	.700	.701	.702	.702	.703	.704	.705
118	.698	.699	.700	.701	.702	.703	.703	.704	.705	.706
120	.699	.700	.701	.702	.703	.704	.704	.705	.706	.707

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.680	0.681	0.682	0.683	0.684	0.685	0.686	0.687	0.688	0.689
	Corresponding specific gravities at 60°/60° F									
30	0.665	0.666	0.667	0.668	0.669	0.670	0.671	0.672	0.673	0.674
32	.666	.667	.668	.669	.670	.671	.672	.673	.674	.675
34	.667	.668	.669	.670	.671	.672	.673	.674	.675	.676
36	.668	.669	.670	.671	.672	.673	.674	.675	.676	.677
38	.669	.670	.671	.672	.673	.674	.675	.676	.677	.678
40	.6700	.6710	.6720	.6730	.6740	.6750	.6760	.6770	.6780	.6790
42	.6710	.6720	.6730	.6740	.6750	.6760	.6770	.6780	.6790	.6800
44	.6720	.6730	.6740	.6750	.6760	.6770	.6780	.6790	.6800	.6810
46	.6730	.6740	.6750	.6760	.6770	.6780	.6790	.6800	.6810	.6820
48	.6740	.6750	.6760	.6770	.6780	.6790	.6800	.6810	.6820	.6830
50	.6750	.6760	.6770	.6780	.6790	.6800	.6810	.6820	.6830	.6840
52	.6760	.6770	.6780	.6790	.6800	.6810	.6820	.6830	.6840	.6850
54	.6770	.6780	.6790	.6800	.6810	.6820	.6830	.6840	.6850	.6860
56	.6780	.6790	.6800	.6810	.6820	.6830	.6840	.6850	.6860	.6870
58	.6790	.6800	.6810	.6820	.6830	.6840	.6850	.6860	.6870	.6880
60	.6800	.6810	.6820	.6830	.6840	.6850	.6860	.6870	.6880	.6890
62	.6810	.6820	.6830	.6840	.6850	.6860	.6870	.6880	.6890	.6900
64	.6820	.6830	.6840	.6850	.6860	.6870	.6880	.6890	.6900	.6910
66	.6830	.6840	.6850	.6860	.6870	.6880	.6890	.6900	.6910	.6920
68	.6840	.6850	.6860	.6870	.6880	.6890	.6900	.6910	.6920	.6930
70	.6850	.6860	.6870	.6880	.6890	.6900	.6910	.6920	.6930	.6940
72	.6860	.6870	.6880	.6890	.6900	.6910	.6920	.6930	.6940	.6950
74	.6870	.6880	.6890	.6900	.6910	.6920	.6925	.6935	.6945	.6955
76	.6875	.6885	.6895	.6905	.6915	.6925	.6935	.6945	.6955	.6965
78	.6885	.6895	.6905	.6915	.6925	.6935	.6945	.6955	.6965	.6975
80	.689	.690	.691	.692	.693	.694	.695	.696	.697	.698
82	.690	.691	.692	.693	.694	.695	.696	.697	.698	.699
84	.691	.692	.693	.694	.695	.696	.697	.698	.699	.700
86	.692	.693	.694	.695	.696	.697	.698	.699	.700	.701
88	.693	.694	.695	.696	.697	.698	.699	.700	.701	.702
90	.694	.695	.696	.697	.698	.699	.700	.701	.702	.703
92	.695	.696	.697	.698	.699	.700	.701	.702	.703	.704
94	.696	.697	.698	.699	.700	.701	.702	.703	.704	.705
96	.697	.698	.699	.700	.701	.702	.703	.704	.705	.706
98	.698	.699	.700	701	.702	.703	.704	.705	.706	.707
100	.699	.700	.701	.702	.703	.704	.705	.706	.707	.708
102	.700	.701	.702	.703	.704	.705	.706	.707	.708	.709
104	.701	.702	.703	.704	.705	.706	.707	.708	.709	.710
106	.702	.703	.704	.705	.706	.707	.708	.709	.710	.711
108	.703	.704	.705	.706	.707	.708	.708	.709	.710	.711
110	.704	.705	.706	.707	.708	.709	.709	.710	.711	.712
112	.705	.706	.707	.708	.709	.710	.710	.711	.712	.713
114	.706	.707	.708	.709	.710	.711	.711	.712	.713	.714
116	.706	.707	.708	.709	.710	.711	.712	.713	.714	.715
118	.707	.708	.709	.710	.711	.712	.713	.714	.715	.716
120	.708	.709	.710	.711	.712	.713	.714	.715	.716	.717

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.690	0.691	0.692	0.693	0.694	0.695	0.696	0.697	0.698	0.699
	Corresponding specific gravities at 60°/60° F									
30	0.675	0.676	0.677	0.678	0.679	0.680	0.681	0.682	0.683	0.684
32	.676	.677	.678	.679	.680	.681	.682	.683	.684	.685
34	.677	.678	.679	.680	681	.682	.683	.684	.685	.686
36	.678	.679	.680	.681	.682	.683	.684	.685	.686	.687
38	.679	.680	.681	.682	.683	.684	.685	.686	.687	.688
40	.6800	.6810	.6820	.6830	.6840	.6850	.6865	.6875	.6885	.6895
42	.6810	.6820	.6830	.6840	.6850	.6860	.6875	.6885	.6895	.6905
44	.6820	.6830	.6840	.6850	.6860	.6870	.6885	.6895	.6905	.6915
46	.6830	.6840	.6850	.6860	.6870	.6880	.6895	.6905	.6915	.6925
48	.6840	.6850	.6860	.6870	.6880	.6890	.6900	.6910	.6920	.6930
50	.6850	.6860	.6870	.6880	.6890	.6900	.6910	.6920	.6930	.6040
52	.6860	.6870	.6880	.6890	.6900	.6910	.6920	.6930	.6940	.6950
54	.6870	.6880	.6890	.6900	.6910	.6920	.6930	.6940	.6950	.6960
56	.6880	.6890	.6900	.6910	.6920	.6930	.6940	.6950	.6960	.6970
58	.6890	.6900	.6910	.6920	.6930	.6940	.6950	.6960	.6970	.6980
60	.6900	.6910	.6920	.6930	.6940	.6950	.6960	.6970	.6980	.6990
62	.6910	.6920	.6930	.6940	.6950	.6960	.6970	.6980	.6990	.7000
64	.6920	.6930	.6940	.6950	.6960	.6970	.6980	.6990	.7000	.7010
66	.6930	.6940	.6950	.6960	.6970	.6980	.6990	.7000	.7010	.7020
68	.6940	.6950	.6960	.6970	.6980	.6990	.7000	.7010	.7020	.7030
70	.6950	.6960	.6970	.6980	.6990	.7000	.7010	.7020	.7030	.7040
72	.6960	.6970	.6980	.6990	.7000	.7010	.7015	.7025	.7035	.7045
74	.6965	.6975	.6985	.6995	.7005	.7015	.7025	.7035	.7045	.7055
76	.6975	.6985	.6995	.7005	.7015	.7025	.7035	.7045	.7055	.7065
78	.6985	.6995	.7005	.7015	.7025	.7035	.7045	.7055	.7065	.7075
80	.699	.700	.701	.702	.703	.704	.705	.706	.707	.708
82	.700	.701	.702	.703	.704	.705	.706	.707	.708	.709
84	.701	.702	.703	.704	.705	.706	.707	.708	.709	.710
86	.702	.703	.704	.705	.706	.707	.708	.709	.710	.711
88	.703	.704	.705	.706	.707	.708	.709	.710	.711	.712
90	.704	.705	.706	.707	.708	.709	.710	.711	.712	.713
92	.705	.706	.707	.708	.709	.710	.711	.712	.713	.714
94	.706	.707	.708	.709	.710	.711	.712	.713	.714	.715
96	.707	.708	.709	.710	.711	.712	.712	.713	.714	.715
98	.708	.709	.710	.711	.712	.713	.713	.714	.715	.716
100	.709	.710	.711	.712	.713	.714	.714	.715	.716	.717
102	.710	.711	.712	.713	.714	.715	.715	.716	.717	.718
104	.711	.712	.713	.714	.715	.716	.716	.717	.718	.719
106	.712	.713	.714	.715	.716	.717	.717	.718	.719	.720
108	.712	.713	.714	.715	.716	.717	.718	.719	.720	.721
110	.713	.714	.715	.716	.717	.718	.719	.720	.721	.722
112	.714	.715	.716	.717	.718	.719	.720	.721	.722	.723
114	.715	.716	717	.718	.719	.720	.721	.722	.723	.724
116	.716	.717	.718	.719	.720	.721	.722	.723	.724	.725
118	.717	.718	.719	.720	.721	.722	.722	.723	.724	.725
120	.718	.719	.720	.721	.722	.723	.723	.724	.725	.726

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.700	0.701	0.702	0.703	0.704	0.705	0.706	0.707	0.708	0.709
	Corresponding specific gravities at 60°/60° F									
30	0.685	0.686	0.687	0.688	0.689	0.690	0.691	0.692	0.693	0.694
32	.686	.687	.688	.689	.690	.691	.692	.693	.694	.695
34	.687	.688	.689	.690	.691	.692	.693	.694	.695	.696
36	.688	.689	.690	.691	.692	.693	.694	.695	.696	.697
38	.689	.690	.691	.692	.693	.694	.695	.696	.697	.698
40	.6905	.6915	.6925	.6935	.6945	.6955	.6965	.6975	.6985	.69[illegible]5
42	.6915	.6925	.6935	.6945	.6955	.6965	.6975	.6985	.6995	.7005
44	.6925	.6935	.6945	.6955	.6965	.6975	.6985	.6995	.7005	.7015
46	.6935	.6945	.6955	.6965	.6975	.6985	.6995	.7005	.7015	.7025
48	.6940	.6950	.6960	.6970	.6980	.6990	.7005	.7015	.7025	.7035
50	.6950	.6960	.6970	.6980	.6990	.7000	.7015	.7025	.7035	.7045
52	.6960	.6970	.6980	.6990	.7000	.7010	.7025	.7035	.7045	.7055
54	.6970	.6980	.6990	.7000	.7010	.7020	.7030	.7040	.7050	.7060
56	.6980	.6990	.7000	.7010	.7020	.7030	.7040	.7050	.7060	.7070
58	.6990	.7000	.7010	.7020	.7030	.7040	.7050	.7060	.7070	7080
60	.7000	.7010	.7020	.7030	.7040	.7050	.7060	.7070	.7080	.7090
62	.7010	.7020	.7030	.7040	.7050	.7060	.7070	.7080	.7090	.7100
64	.7020	.7030	.7040	.7050	.7060	.7070	.7080	.7090	.7100	.7110
66	.7030	.7040	.7050	.7060	.7070	.7080	.7090	.7100	.7110	.7120
68	.7040	.7050	.7060	.7070	.7080	.7090	.7095	.7105	.7115	.7125
70	.7050	.7060	.7070	.7080	.7090	.7100	.7105	.7115	.7125	.7135
72	.7055	.7065	.7075	.7085	.7095	.7105	.7115	.7125	.7135	.7145
74	.7065	.7075	.7085	.7095	.7105	.7115	.7125	.7135	.7145	.7155
76	.7075	.7085	.7095	.7105	.7115	.7125	.7135	.7145	.7155	.7165
78	.7085	.7095	.7105	.7115	.7125	.7135	.7145	.7155	.7165	.7175
80	.709	.710	.711	.712	.713	.714	.715	.716	.717	.718
82	.710	.711	.712	.713	.714	.715	.716	.717	.718	.719
84	.711	.712	.713	.714	.715	.716	.717	.718	.719	.720
86	.712	.713	.714	.715	.716	.717	.718	.719	.720	.721
88	.713	.714	.715	.716	.717	.718	.719	.720	.721	.722
90	.714	.715	.716	.717	.718	.719	.720	.721	.722	.723
92	.715	.716	.717	.718	.719	.720	.720	.721	.722	.723
94	.716	.717	.718	.719	.720	.721	.721	.722	.723	.724
96	.716	.717	.718	.719	.720	.721	.722	.723	.724	.725
98	.717	.718	.719	.720	.721	.722	.723	.724	.725	.726
100	.718	.719	.720	.721	.722	.723	.724	.725	.726	.727
102	.719	.720	.721	.722	.723	.724	.725	.726	.727	.728
104	.720	.721	.722	.723	.724	.725	.726	.727	.728	.729
106	.721	.722	.723	.724	.725	.726	.727	.728	.729	.730
108	.722	.723	.724	.725	.726	.727	.728	.729	.730	.731
110	.723	.724	.725	.726	.727	.728	.729	.730	.731	.732
112	.724	.725	.726	.727	.728	.729	.730	.731	.732	.733
114	.725	.726	.727	.728	.729	.730	.731	.732	.733	.734
116	.726	.727	.728	.729	.730	.731	.731	.732	.733	.734
118	.726	.727	.728	.729	.730	.731	.732	.733	.734	.735
120	.727	.728	.729	.730	.731	.732	.733	.734	.735	.736

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.710	0.711	0.712	0.713	0.714	0.715	0.716	0.717	0.718	0.719
	Corresponding specific gravities at 60°/60° F									
30	0.695	0.696	0.967	0.698	0.699	0.700	0.701	0.702	0.703	0.704
32	.696	.697	.698	.699	.700	.701	.702	.703	.704	.705
34	.697	.698	.699	.700	.701	.702	.703	.704	.705	.706
36	.698	.699	.700	.701	.702	.703	.704	.705	.706	.707
38	.699	.700	.701	.702	.703	.704	.705	.706	.707	.708
40	.7005	.7015	.7025	.7035	.7045	.7055	.7065	.7075	.7085	7095
42	.7015	.7025	.7035	.7045	.7055	.7065	.7075	.7085	.7095	.7105
44	.7025	.7035	.7045	.7055	.7065	.7075	.7085	.7095	.7105	.7115
46	.7035	.7045	.7055	.7065	.7075	.7585	.7095	.7105	.7115	.7125
48	.7045	.7055	.8065	.7075	.7085	.7095	.7105	.7115	.7125	.7135
50	.7055	.7065	.7075	.7085	.7095	.7105	.7115	.7125	.7135	.7145
52	.7065	.7075	.7085	.7095	.7105	.7115	.7125	.7135	.7145	.7155
54	.7070	.7080	.7090	.7100	.7100	.7120	.7130	.7140	.7150	.7160
56	.7080	.7090	.7100	.7110	.7120	.7130	.7140	.7150	.7160	.7170
58	.7090	.7100	.7110	.7120	.7130	.7140	.7150	.7160	.7170	.7180
60	.7100	.7110	.7120	.7130	.7140	.7150	.7160	.7170	.7180	.7190
62	.7110	.7120	.7130	.7140	.7150	.7160	.7170	.7180	.7190	.7200
64	.7120	.7130	.7140	.7150	.7160	.7170	.7180	.7190	.7200	.7210
66	.7130	.7140	.7150	.7160	.7170	.7180	.7185	.7195	.7205	.7215
68	.7135	.7145	.7155	.7165	.7175	.7185	.7195	.7205	.7215	.7225
70	.7145	.7155	.7165	.7175	.7185	.7195	.7205	.7215	.7225	.7235
72	.7155	.7165	.7175	.7185	.7195	.7205	.7215	.7225	.7235	.7245
74	.7165	.7175	.7185	.7195	.7205	.7215	.7225	.7235	.7245	.7255
76	.7175	.7185	.7195	.7205	.7215	.7225	.7235	.7245	.7255	.7265
78	.7185	.7195	.7205	.7215	.7225	.7235	.7245	.7255	.7265	.7275
80	.719	.720	.721	.722	.723	.724	.725	.726	.727	.728
82	.720	.721	.722	.723	.724	.725	.726	.727	.728	.729
84	.721	.722	.723	.724	.725	.726	.727	.728	.729	.730
86	.722	.723	.724	.725	.726	.727	.728	.729	.730	.731
88	.723	.724	.725	.726	.727	.728	.729	.730	.731	.732
90	.724	.725	.726	.727	.728	.729	.729	.730	.731	.732
92	.724	.725	.726	.727	.728	.729	.730	.731	.732	.733
94	.725	.726	.727	.728	.729	.730	.731	.732	.733	.734
96	.726	.727	.728	.729	.730	.731	.732	.733	.734	.735
98	.727	.728	.729	.730	.731	.732	.733	.734	.735	.736
100	.728	.729	.730	.731	.732	.733	.734	.735	.736	.737
102	.729	.730	.731	.732	.733	.734	.735	.736	.737	.738
104	.730	.731	.732	.733	.734	.735	.736	.737	.738	.739
106	.731	.732	.733	.734	.735	.736	.737	.738	.739	.740
108	.732	.733	.734	.735	.736	.737	.737	.738	.739	.740
110	.733	.734	.735	.736	.737	.738	.738	.739	.740	.741
112	.734	.735	.736	.737	.738	.739	.739	.740	.741	.742
114	.734	.735	.736	.737	.738	.739	.740	.741	.742	.743
116	.735	.736	.737	.738	.739	.740	.741	.742	.743	.744
118	.736	.737	.738	.739	.740	.741	.742	.743	.744	.745
120	.737	.738	.739	.740	.741	.742	.742	.743	.744	.745

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.720	0.721	0.722	0.723	0.724	0.725	0.726	0.727	0.728	0.729
	Corresponding specific gravities at 60°/60° F									
30	0.705	0.706	0.707	0.708	0.709	0.710	0.712	0.713	0.714	0.715
32	.706	.707	.708	.709	.710	.711	.713	.714	.715	.716
34	.707	.708	.709	.710	.711	.712	.714	.715	.716	.717
36	.708	.709	.710	.711	.712	.713	.715	.716	.717	.718
38	.709	.710	.711	.712	.713	.714	.716	.717	.718	.719
40	.7105	.7115	.7125	.7135	.7145	.7155	.7165	.7175	.7185	.7195
42	.7115	.7125	.7135	.7145	.7155	.7165	.7175	.7185	.7195	.7205
44	.7125	.7135	.7145	.7155	.7165	.7175	.7185	.7195	.7205	.7215
46	.7135	.7145	.7155	.7165	.7175	.7185	.7195	.7205	.7215	.7225
48	.7145	.7155	.7165	.7175	.7185	.7195	.7205	.7215	.7225	.7235
50	.7155	.7165	.7175	.7185	.7195	.7205	.7215	.7225	.7235	.7245
52	.7165	.7175	.7185	.7195	.7205	.7215	.7225	.7235	.7245	.7255
54	.7170	.7180	.7190	.7200	.7210	.7220	.7230	.7240	.7250	.7260
56	.7180	.7190	.7200	.7210	.7220	.7230	.7240	.7250	.7260	.7270
58	.7190	.7200	.7210	.7220	.7230	.7240	.7250	.7260	.7270	.7280
60	.7200	.7210	.7220	.7230	.7240	.7250	.7260	.7270	.7280	.7290
62	.7210	.7220	.7230	.7240	.7250	.7260	.7270	.7280	.7290	.7300
64	.7220	.7230	.7240	.7250	.7260	.7270	.7280	.7290	.7300	.7310
66	.7225	.7235	.7245	.7255	.7265	.7275	.7285	.7295	.7305	.7315
68	.7235	.7245	.7255	.7265	.7275	.7285	.7295	.7305	.7315	.7325
70	.7245	.7255	.7265	.7275	.7285	.7295	.7305	.7315	.7325	.7335
72	.7255	.7265	.7275	.7285	.7295	.7305	.7315	.7325	.7335	.7345
74	.7265	.7275	.7285	.7295	.7305	.7315	.7325	.7335	.7345	.7355
76	.7275	.7285	.7295	.7305	.7315	.7325	.7330	.7340	.7350	.7360
78	.7285	.7295	.7305	.7315	.7325	.7335	.7340	.7350	.7360	.7370
80	.729	.730	.731	.732	.733	.734	.735	.736	.737	.738
82	.730	.731	.732	.733	.734	.735	.736	.737	.738	.739
84	.731	.732	.733	.734	.735	.736	.737	.738	.739	.740
86	.732	.733	.734	.735	.736	.737	.737	.738	.739	.740
88	.733	.734	.735	.736	.737	.738	.738	.739	.740	.741
90	.733	.734	.735	.736	.737	.738	.739	.740	.741	.742
92	.734	.735	.736	.737	.738	.739	.740	.741	.742	.743
94	.735	.736	.737	.738	.739	.740	.741	.742	.743	.744
96	.736	.737	.738	.739	.740	.741	.742	.743	.744	.745
98	.737	.738	.739	.740	.741	.742	.743	.744	.745	.746
100	.738	.739	.740	.741	.742	.743	.743	.744	.745	.746
102	.739	.740	.741	.742	.743	.744	.744	.745	.746	.747
104	.740	.741	.742	.743	.744	.745	.745	.746	.747	.748
106	.741	.742	.743	.744	.745	.746	.746	.747	.748	.749
108	.741	742	.743	.744	.745	.746	.747	.748	.749	.750
110	.742	.743	.744	.745	.746	.747	.748	.749	.750	.751
112	.743	.744	.745	.746	.747	.748	.749	.750	.751	.752
114	.744	.745	.746	.747	.748	.749	.749	.750	.751	.752
116	.745	.746	.747	.748	.749	.750	.750	.751	.752	.753
118	.746	.747	.748	.749	.750	.751	.751	.752	.753	.754
120	.746	.747	.748	.749	.750	.751	.752	.753	.754	.755

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.730	0.731	0.732	0.733	0.734	0.735	0.736	0.737	0.738	0.739
	Corresponding specific gravities at 60°/60° F									
30	0.716	0.717	0.718	0.719	0.720	0.721	0.722	0.723	0.724	0.725
32	.717	.718	.719	.720	.721	.722	.723	.724	.725	.726
34	.718	.719	.720	.721	.722	.723	.724	.725	.726	.727
36	.719	.720	.721	.722	.723	.724	.725	.726	.727	.728
38	.720	.721	.722	723	.724	.725	.726	.727	.728	.729
40	.7205	.7215	.7225	.7235	.7245	.7255	.7270	.7280	.7290	.7300
42	.7215	.7225	.7235	7245	.7255	.7265	.7275	.7285	.7295	.7305
44	.7225	.7235	.7245	.7255	.7265	.7275	.7285	.7295	.7305	.7315
46	7235	.7245	.7255	.7265	.7275	.7285	.7295	.7305	.7315	.7325
48	.7245	.7255	7265	.7275	.7285	.7295	.7305	.7315	.7325	.7335
50	.7255	.7265	.7275	7285	.7295	.7305	.7315	.7325	.7335	.7345
52	.7265	.7275	.7285	.7295	.7305	.7315	.7325	.7335	.7345	.7355
54	.7270	.7280	.7290	.7300	.7310	.7320	.7330	.7340	.7350	.7360
56	.7280	.7290	.7300	.7310	.7320	.7330	.7340	.7350	.7360	.7370
58	.7290	.7300	.7310	7320	.7330	.7340	.7350	.7360	.7370	.7380
60	.7300	.7310	.7320	.7330	.7340	.7350	.7360	.7370	.7380	.7390
62	.7310	.7320	.7330	.7340	.7350	.7360	.7370	.7380	.7390	.7400
64	.7320	.7330	.7340	.7350	.7360	.7370	.7375	.7385	.7395	.7405
66	.7325	.7335	.7345	.7355	.7365	.7375	.7385	.7395	.7405	.7415
68	.7335	.7345	.7355	.7365	.7375	.7385	.7395	.7405	.7415	.7425
70	.7345	.7355	.7365	.7375	.7385	.7395	.7405	.7415	.7425	.7435
72	.7355	.7365	.7375	.7385	.7395	.7405	.7410	.7420	.7430	.7440
74	.7365	.7375	.7385	.7395	7405	.7415	.7420	.7430	.7440	.7450
76	.7370	7380	.7390	.7400	.7410	.7420	.7430	.7440	.7450	.7460
78	.7380	.7390	.7400	.7410	.7420	.7430	.7440	.7450	.7460	.7470
80	.739	.740	.741	.742	.743	.744	.744	.745	.746	.747
82	.740	.741	.742	.743	744	.745	.745	.746	.747	.748
84	.741	.742	.743	.744	.745	.746	.746	.747	.748	.749
86	.741	.742	.743	.744	.745	.746	.747	.748	.749	.750
88	.742	.743	.744	.745	.746	.747	.748	.749	.750	.751
90	.743	.744	.745	.746	.747	.748	.749	.750	.751	.752
92	.744	.745	.746	.747	.748	.749	.750	.751	.752	.753
94	.745	.746	.747	.748	.749	.750	.751	.752	.753	.754
96	.746	.747	.748	.749	.750	.751	.751	.752	.753	.754
98	.747	.748	.749	.750	.751	.752	.752	.753	.754	.755
100	.747	.748	.749	.750	.751	.752	.753	.754	.755	.756
102	.748	.749	.750	.751	.752	.753	.754	.755	.756	.757
104	.749	.750	.751	.752	.753	.754	.755	.756	.757	.758
106	.750	.751	.752	.753	.754	.755	.756	.757	.758	.759
108	.751	.752	.753	.754	.755	.756	.756	.757	.758	.759
110	.752	.753	.754	.755	.756	.757	.757	.758	.759	.760
112	.753	.754	.755	.756	.757	.758	.758	.759	.760	.761
114	.753	.754	.755	.756	.757	.758	.759	.760	.761	.762
116	.754	.755	.756	.757	.758	.759	.760	.761	.762	.763
118	.755	.756	.757	.758	.759	.760	.761	.762	.763	.764
120	.756	.757	.758	.759	.760	.761	.761	.762	.763	.764

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.740	0.741	0.742	0.743	0.744	0.745	0.746	0.747	0.748	0.749
	Corresponding specific gravities at 60°/60° F									
30	0.726	0.727	0.728	0.729	0.730	0.731	0.732	0.733	0.734	0.735
32	.727	.728	.729	.730	.731	.732	.733	.734	.735	.736
34	.728	.729	.730	.731	.732	.733	.734	.735	.736	.737
36	.729	.730	.731	.732	.733	.734	.735	.736	.737	.738
38	.730	.731	.732	.733	.734	.735	.736	.737	.738	.739
40	.7310	.7320	.7330	.7340	.7350	.7360	.7370	.7380	.7390	.7400
42	.7315	.7325	.7335	.7345	.7355	.7365	.7380	.7390	.7400	.7410
44	.7325	.7335	.7345	.7355	.7365	.7375	.7390	.7400	.7410	.7420
46	.7335	.7345	.7355	.7365	.7375	.7385	.7400	.7410	.7420	.7430
48	.7345	.7355	.7365	.7375	.7385	.7395	.7405	.7415	.7425	.7435
50	.7355	.7365	.7375	.7385	.7395	.7405	.7415	.7425	.7435	.7445
52	.7365	.7375	.7385	.7395	.7405	.7415	.7425	.7435	.7445	.7455
54	.7370	.7380	.7390	.7400	.7410	.7420	.7435	.7445	.7455	.7465
56	.7380	.7390	.7400	.7410	.7420	.7430	.7440	.7450	.7460	.7470
58	.7390	.7400	.7410	.7420	.7430	.7440	.7450	.7460	.7470	.7480
60	.7400	.7410	.7420	.7430	.7440	.7450	.7460	.7470	.7480	.7490
62	.7410	.7420	.7430	.7440	.7450	.7460	.7470	.7480	.7490	.7500
64	.7415	.7425	.7435	.7445	.7455	.7465	.7475	.7485	.7495	.7505
66	.7425	.7435	.7445	.7455	.7465	.7475	.7485	.7495	.7505	.7515
68	.7435	.7445	.7455	.7465	.7475	.7485	.7495	.7505	.7515	.7525
70	.7445	.7455	.7465	.7475	.7485	.7495	.7505	.7515	.7525	.7535
72	.7450	.7460	.7470	.7480	.7490	.7500	.7510	.7520	.7530	.7540
74	.7460	.7470	.7480	.7490	.7500	.7510	.7520	.7530	.7540	.7550
76	.7470	.7480	.7490	.7500	.7510	.7520	.7530	.7540	.7550	.7560
78	.7480	.7490	.7500	.7510	.7520	.7530	.7540	.7550	.7560	.7570
80	.748	.749	.750	.751	.752	.753	.754	.755	.756	.757
82	.749	.750	.751	.752	.753	.754	.755	.756	.757	.758
84	.750	.751	.752	.753	.754	.755	.756	.757	.758	.759
86	.751	.752	.753	.754	.755	.756	.757	.758	.759	.760
88	.752	.753	.754	.755	.756	.757	.758	.759	.760	.761
90	.753	.754	.755	.756	.757	.758	.759	.760	.761	.762
92	.754	.755	.756	.757	.758	.759	.759	.760	.761	.762
94	.755	.756	.757	.758	.759	.760	.760	.761	.762	.763
96	.755	.756	.757	.758	.759	.760	.761	.762	.763	.764
98	.756	.757	.758	.759	.760	.761	.762	.763	.764	.765
100	.757	.758	.759	.760	.761	.762	.763	.764	.765	.766
102	.758	.759	.760	.761	.762	.763	.764	.765	.766	.767
104	.759	.760	.761	.762	.763	.764	.764	.765	.766	.767
106	.760	.761	.762	.763	.764	.765	.765	.766	.767	.768
108	.760	.761	.762	.763	.764	.765	.766	.767	.768	.769
110	.761	.762	.763	.764	.765	.766	.767	.768	.769	.770
112	.762	.763	.764	.765	.766	.767	.768	.769	.770	.771
114	.763	.764	.765	.766	.767	.768	.768	.769	.770	.771
116	.764	.765	.766	.767	.768	.769	.769	.770	.771	.772
118	.765	.766	.767	.768	.769	.770	.770	.771	.772	.773
120	.765	.766	.767	.768	.769	.770	.771	.772	.773	.774

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.750	0.751	0.752	0.753	0.754	0.755	0.756	0.757	0.758	0.759
	Corresponding specific gravities at 60°/60° F									
30	0.736	0.737	0.738	0.739	0.740	0.741	0.742	0.743	0.744	0.745
32	.737	.738	.739	.740	.741	.742	.743	.744	.745	.746
34	.738	.739	.740	.741	.742	.743	.744	.745	.746	.747
36	.739	.740	.741	.742	.743	.744	.745	.746	.747	.748
38	.740	.741	.742	.743	744	.745	.746	.747	.748	.749
40	.7410	.7420	.7430	.7440	.7450	.7460	.7475	.7485	.7495	.7505
42	.7420	.7430	7440	.7450	.7460	.7470	.7480	.7490	.7500	.7510
44	.7430	.7440	.7450	.7460	.7470	.7480	.7490	.7500	.7510	.7520
46	.7440	.7450	.7460	.7470	.7480	.7490	.7500	.7510	.7520	.7530
48	.7445	.7455	.7465	.7475	.7485	.7495	.7510	.7520	.7530	.7540
50	.7455	.7465	.7475	.7485	.7495	.7505	.7515	.7525	.7535	.7545
52	.7465	.7475	.7485	.7495	.7505	.7515	.7525	.7535	.7545	.7555
54	.7475	.7485	.7495	.7505	.7515	.7525	.7535	.7545	.7555	.7565
56	.7480	.7490	.7500	.7510	.7520	.7530	.7540	.7550	.7560	.7570
58	.7490	.7500	.7510	.7520	.7530	.7540	.7550	.7560	.7570	.7580
60	.7500	.7510	.7520	.7530	.7540	.7550	.7560	.7570	.7580	.7590
62	.7510	.7520	.7530	.7540	.7550	.7560	.7570	.7580	.7590	.7600
64	.7515	.7525	.7535	.7545	.7555	.7565	.7575	.7585	.7595	.7605
66	.7525	.7535	.7545	.7555	.7565	.7675	.7585	.7595	.7605	.7615
68	.7535	.7545	.7555	.7565	.7575	.7585	.7590	.7600	.7610	.7620
70	7545	.7555	.7565	.7575	.7585	.7595	.7600	.7610	.7620	.7630
72	.7550	.7560	.7570	7580	.7590	.7600	.7610	.7620	.7630	.7640
74	.7560	7570	.7580	.7590	7600	.7610	.7615	.7625	.7635	.7645
76	.7570	.7580	7590	.7600	.7610	.7620	.7625	.7635	.7645	.7655
78	.7580	.7590	.7600	7610	7620	.7630	.7635	.7645	.7655	.7665
80	.758	.759	.760	.761	.762	.763	.764	.765	.766	.767
82	.759	.760	.761	.762	.763	.764	.765	.766	.767	.768
84	.760	.761	.762	.763	.764	.765	.766	.767	.768	.769
86	.761	.762	.763	.764	.765	.766	.767	.768	.769	.770
88	.762	.763	.764	.765	.766	.767	.767	.768	.769	.770
90	.763	.764	.765	.766	.767	.768	.768	.769	.770	.771
92	.763	.764	.765	.766	.767	.768	.769	.770	.771	.772
94	.764	.765	.766	.767	.768	.769	.770	.771	.772	.773
96	.765	.766	.767	.768	.769	.770	.771	.772	.773	.774
98	.766	.767	.768	.769	.770	.771	.771	.772	.773	.774
100	.767	.768	.769	.770	.771	.772	.772	.773	.774	.775
102	.768	.769	.770	.771	.772	.773	.773	.774	.775	.776
104	.768	.769	.770	.771	.772	.773	.774	.775	.776	.777
106	.769	.770	.771	.772	.773	.774	.775	.776	.777	.778
108	.770	.771	.772	.773	.774	.775	.775	.776	.777	.778
110	.771	.772	.773	.774	.775	.776	.776	.777	.778	.779
112	.772	.773	.774	.775	.776	.777	.777	.778	.779	.780
114	.772	.773	.774	.775	.776	.777	.778	.779	.780	.781
116	.773	.774	.775	.776	.777	.778	.779	.780	.781	.782
118	.774	.775	.776	.777	.778	.779	.780	.781	.782	.783
120	.775	.776	.777	.778	.779	.780	.780	.781	.782	.783

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.760	0.761	0.762	0.763	0.764	0.765	0.766	0.767	0.768	0.769
	Corresponding specific gravities at 60°/60° F									
30	0.746	0.747	0.748	0.749	0.750	0.751	0.753	0.754	0.755	0.756
32	.747	.748	.749	.750	.751	.752	.754	.755	.756	.757
34	.748	.749	.750	.751	.752	.753	.755	.756	.757	.758
36	.749	.750	.751	.752	.753	.754	.756	.757	.758	.759
38	.750	.751	.752	.753	.754	.755	.757	.758	.759	.760
40	.7515	.7525	.7535	.7545	.7555	.7565	.7575	.7585	.7595	.7605
42	.7520	.7530	.7540	.7550	.7560	.7570	.7585	.7595	.7605	.7615
44	.7530	.7540	.7550	.7560	.7570	.7580	.7590	.7600	.7610	.7620
46	.7540	.7550	.7560	.7570	.7580	.7590	.7600	.7610	.7620	.7630
48	.7550	.7560	.7570	.7580	.7590	.7600	.7610	.7620	.7630	.7640
50	.7555	.7565	.7575	.7585	.7595	.7605	.7620	.7630	.7640	.7650
52	.7565	.7575	.7585	.7595	.7605	.7615	.7625	.7635	.7645	.7655
54	.7575	.7585	.7595	.7605	.7615	.7625	.7635	.7645	.7655	.7665
56	.7580	.7590	.7600	.7610	.7620	.7630	.7645	.7655	.7665	.7675
58	.7590	.7600	.7610	.7620	.7630	.7640	.7650	.7660	.7670	.7680
60	.7600	.7610	.7620	.7630	.7640	.7650	.7660	.7670	.7680	.7690
62	.7610	.7620	.7630	.7640	.7650	.7660	.7670	.7680	.7690	.7700
64	.7615	.7625	.7635	.7645	.7655	.7665	.7675	.7685	.7695	.7705
66	.7625	.7635	.7645	.7655	.7665	.7675	.7685	.7695	.7705	.7715
68	.7630	.7640	.7650	.7660	.7670	.7680	.7690	.7700	.7710	.7720
70	.7640	.7650	.7660	.7670	.7680	.7690	.7700	.7710	.7720	.7730
72	.7650	.7660	.7670	.7680	.7690	.7700	.7710	.7720	.7730	.7740
74	.7655	.7665	.7675	.7685	.7695	.7705	.7715	.7725	.7735	.7745
76	.7665	.7675	.7685	.7695	.7705	.7715	.7725	.7735	.7745	.7755
78	.7675	.7685	.7695	.7705	.7715	.7725	.7735	.7745	.7755	.7765
80	.768	.769	.770	.771	.772	.773	.774	.775	.776	.777
82	.769	.770	.771	.772	.773	.774	.775	.776	.777	.778
84	.770	.771	.772	.773	.774	.775	.776	.777	.778	.779
86	.771	.772	.773	.774	.775	.776	.776	.777	.778	.778
88	.771	.772	.773	.774	.775	.776	.777	.778	.779	.780
90	.772	.773	.774	.775	.776	.777	.778	.779	.780	.781
92	.773	.774	.775	.776	.777	.778	.779	.780	.781	.782
94	.774	.775	.776	.777	.778	.779	.780	.781	.782	.783
96	.775	.776	.777	.778	.779	.780	.780	.781	.782	.783
98	.775	.776	.777	.778	.779	.780	.781	.782	.783	.784
100	.776	.777	.778	.779	.780	.781	.782	.783	.784	.785
102	.777	.778	.779	.780	.781	.782	.783	.784	.785	.786
104	.778	.779	.780	.781	.782	.783	.784	.785	.786	.787
106	.779	.780	.781	.782	.783	.784	.784	.785	.786	.787
108	.779	.780	.781	.782	.783	.784	.785	.786	.787	.788
110	.780	.781	.782	.783	.784	.785	.786	.787	.788	.789
112	.781	.782	.783	.784	.785	.786	.787	.788	.789	.790
114	.782	.783	.784	.785	.786	.787	.787	.788	.789	.790
116	.783	.784	.785	.786	.787	.788	.788	.789	.790	.791
118	.784	.785	.786	.787	.788	.789	.789	.790	.791	.792
120	.784	.785	.786	.787	.788	.789	.790	.791	.792	.793

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.770	0.771	0.772	0.773	0.774	0.775	0.776	0.777	0.778	0.779
	Corresponding specific gravities at 60°/60° F									
30	0.757	0.758	0.759	0.760	0.761	0.762	0.763	0.764	0.765	0.766
32	.758	.759	.760	.761	.762	.763	.764	.765	.766	.767
34	.759	.760	.761	.762	.763	.764	.765	.766	.767	.768
36	.760	.761	.762	.763	.764	.765	.766	.767	.768	.769
38	.761	.762	.763	.764	.765	.766	.767	.768	.769	.770
40	.7615	.7625	.7635	.7645	.7655	.7665	.7675	.7685	.7695	.7705
42	.7625	.7635	.7645	.7655	.7665	.7675	.7685	.7695	.7705	.7715
44	.7630	.7640	.7650	.7660	.7670	.7680	.7695	.7705	.7715	.7725
46	.7640	.7650	.7660	.7670	.7680	.7690	.7700	.7710	.7720	.7730
48	.7650	.7660	.7670	.7680	.7690	.7700	.7710	.7720	.7730	.77[illegible]0
50	.7660	.7670	.7680	.7690	.7700	.7710	.7720	.7730	.7740	.7750
52	.7665	.7675	.7685	.7695	.7705	.7715	.7725	.7735	.7745	.7755
54	.7675	.7685	.7695	.7705	.7715	.7725	.7735	.7745	.7755	.7765
56	.7685	.7695	.7705	.7715	.7725	.7735	.7745	.7755	.7765	.7775
58	.7690	.7700	.7710	.7720	.7730	.7740	.7750	.7760	.7770	.7780
60	.7700	.7710	.7720	.7730	.7740	.7750	.7760	.7770	.7780	.7790
62	.7710	.7720	.7730	.7740	.7750	.7760	.7770	.7780	.7790	.7800
64	.7715	.7725	.7735	.7745	.7755	.7765	.7775	.7785	.7795	.7805
66	.7725	.7735	.7745	.7755	.7765	.7775	.7785	.7795	.7805	.7815
68	.7730	.7740	.7750	.7760	.7770	.7780	.7790	.7800	.7810	.7820
70	.7740	.7750	.7760	.7770	.7780	.7790	.7800	.7810	.7820	.7830
72	.7750	.7760	.7770	.7780	.7790	.7800	.7810	.7820	.7830	.7840
74	.7755	.7765	.7775	.7785	.7795	.7805	.7815	.7825	.7835	.7845
76	.7765	.7775	.7785	.7795	.7805	.7815	.7825	.7835	.7845	.7855
78	.7775	.7785	.7795	.7805	.7815	.7825	.7835	.7845	.7855	.7865
80	.778	.779	.780	.781	.782	.783	.784	.785	.786	.787
82	.779	.780	.781	.782	.783	.784	.785	.786	.787	.788
84	.780	.781	.782	.783	.784	.785	.785	.786	.787	.788
86	.780	.781	.782	.783	.784	.785	.786	.787	.788	.789
88	.781	.782	.783	.784	.785	.786	.787	.788	.789	.790
90	.782	.783	.784	.785	.786	.787	.788	.789	.790	.791
92	.783	.784	.785	786	.787	.788	.789	.790	.791	.792
94	.784	.785	.786	.787	.788	.789	.789	.790	.791	.792
96	.784	.785	.786	.787	.788	.789	.790	.791	.792	.793
98	.785	.786	.787	.788	.789	.790	.791	.792	.793	.794
100	.786	.787	.788	.789	.790	.791	.792	.793	.794	.795
102	.787	.788	.789	.790	.791	.792	.792	.793	.794	.795
104	.788	.789	.790	791	.792	.793	.793	.794	.795	.796
106	.788	.789	.790	.791	.792	.793	.794	.795	.796	.797
108	.789	.790	.791	.792	.793	.794	.795	.796	.797	.798
110	.790	.791	.792	.793	.794	.795	.795	.796	.797	.798
112	.791	.792	.793	794	.795	.796	.796	.797	.798	.799
114	.791	.792	.793	.794	.795	.796	.797	.798	.799	8.00
116	.792	.793	.794	.795	.796	.797	.798	.799	.800	.801
118	.793	.794	.795	.796	.797	.798	.799	.800	.801	.802
120	.794	.795	.796	.797	.798	.799	.799	.800	.801	.802

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.780	0.781	0.782	0.783	0.784	0.785	0.786	0.787	0.788	0.789
	Corresponding specific gravities at 60°/60° F									
30	0.767	0.768	0.769	0.770	0.771	0.772	0.773	0.774	0.775	0.776
32	.768	.769	.770	.771	.772	.773	.774	.775	.776	.777
34	.769	.770	.771	.772	.773	.774	.775	.776	.777	.778
36	.770	.771	.772	.773	.774	.775	.776	.777	.778	.779
38	.771	.772	.773	.774	.775	.776	.777	.778	.779	.780
40	.7715	.7725	.7735	.7745	.7755	.7765	.7780	.7790	.7800	.7810
42	.7725	.7735	.7745	.7755	.7765	.7775	.7785	.7795	.7805	.7815
44	.7735	.7745	.7755	.7765	.7775	.7785	.7795	.7805	.7815	.7825
46	.7740	.7750	.7760	.7770	.7780	.7790	.7805	.7815	.7825	.7835
48	.7750	.7760	.7770	.7780	.7790	.7800	.7810	.7820	.7830	.7840
50	.7760	.7770	.7780	.7790	.7800	.7810	.7820	.7830	.7840	.7850
52	.7765	.7775	.7785	.7795	.7805	.7815	.7830	.7840	.7850	.7860
54	.7775	.7785	.7795	.7805	.7815	.7825	.7835	.7845	.7855	.7865
56	.7785	.7795	.7805	.7815	.7825	.7835	.7845	.7855	.7865	.7875
58	.7790	.7800	.7810	.7820	.7830	.7840	.7850	.7860	.7870	.7880
60	.7800	.7810	.7820	.7830	.7840	.7850	.7860	.7870	.7880	.7890
62	7810	.7820	.7830	.7840	.7850	.7860	.7865	.7875	.7885	.7895
64	.7815	.7825	.7835	.7845	.7855	.7865	.7875	.7885	.7895	.7905
66	.7825	.7835	.7845	.7855	.7865	.7875	.7885	.7895	.7905	.7915
68	.7830	.7840	.7850	.7860	.7870	.7880	.7890	.7900	.7910	.7920
70	.7840	.7850	7860	.7870	.7880	.7890	.7900	.7910	.7920	.7930
72	.7850	.7860	.7870	.7880	.7890	.7900	.7905	.7915	.7925	.7935
74	7855	.7865	.7875	.7885	.7895	.7905	.7915	.7925	.7935	.7945
76	.7865	.7875	.7885	.7895	.7905	.7915	.7925	.7935	.7945	.7955
78	.7875	.7885	.7895	.7905	.7915	.7925	.7930	.7940	.7450	.7960
80	.788	.789	.790	.791	.792	.793	.794	.795	.796	.797
82	.789	.790	.791	.792	.793	.794	.794	.795	.796	.797
84	.789	.790	.791	.792	793	.794	.795	.796	.797	.798
86	.790	.791	.792	.793	.794	.795	.796	.797	.798	.799
88	.791	.792	.793	.794	.795	.796	.797	.798	.799	.800
90	.792	.793	.794	.795	.796	.797	.798	.799	.800	.801
92	.793	.794	.795	.796	.797	.798	.798	.799	.800	.801
94	.793	.794	.795	.796	.797	.798	.799	.800	.801	.802
96	794	.795	.796	.797	.798	.799	.800	.801	.802	.803
98	.795	.796	.797	.798	.799	.800	.801	.802	.803	.804
100	.796	.797	.798	.799	.800	.801	.801	.802	.803	.804
102	.796	.797	.798	.799	.800	.801	.802	.803	.804	.805
104	797	.798	.799	.800	.801	.802	.803	.804	.805	.806
106	798	.799	.800	.801	.802	.803	.804	.805	.806	.807
108	.799	.800	.801	.802	.803	.804	.804	.805	.806	.807
110	.799	.800	.801	.802	.803	.804	.805	.806	.807	.808
112	.800	.801	.802	.803	.804	.805	.806	.807	.808	.809
114	.801	.802	.803	.804	.805	.806	.807	.808	.809	.810
116	.802	.803	.804	.805	.806	.807	.807	.808	.809	.810
118	.803	.804	.805	.806	.807	.808	.808	.809	.810	.811
120	.803	804	.805	.806	.807	.808	.809	.810	.811	.812

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.790	0.791	0.792	0.793	0.794	0.795	0.796	0.797	0.798	0.799
	Corresponding specific gravities at 60°/60° F									
30	0.777	0.778	0.779	0.780	0.781	0.782	0.784	0.785	0.786	0.787
32	.778	.779	.780	.781	.782	.783	.784	.785	.786	.787
34	.779	.780	.781	.782	.783	.784	.785	.786	.787	.788
36	.780	.781	.782	.783	.784	.785	.786	.787	.788	.789
38	.781	.782	.783	.784	.785	.786	.787	.788	.789	.790
40	.7820	.7830	.7840	.7850	.7860	.7870	.7880	.7890	.7900	.7910
42	.7825	.7835	.7845	.7855	.7865	.7875	.7890	.7900	.7910	.7920
44	.7835	.7845	.7855	.7865	.7875	.7885	.7895	.7905	.7915	.7925
46	.7845	.7855	.7865	.7875	.7885	.7895	.7905	.7915	.7925	.7935
48	.7850	.7860	.7870	.7880	.7890	.7900	.7910	.7920	.7930	.7940
50	.7860	.7870	.7880	.7890	.7900	.7910	.7920	.7930	.7940	.7950
52	.7870	.7880	.7890	.7900	.7910	.7920	.7930	.7940	.7950	.7960
54	.7875	.7885	.7895	.7905	.7915	.7925	.7935	.7945	.7955	.7965
56	.7885	.7895	.7905	.7915	.7925	.7935	.7945	.7955	.7965	.7975
58	.7890	.7900	.7910	.7920	.7930	.7940	.7955	.7965	.7975	.7985
60	.7900	.7910	.7920	.7930	.7940	.7950	.7960	.7970	.7980	.7990
62	7905	.7915	.7925	.7935	.7945	.7955	.7965	.7975	.7985	.7995
64	.7915	.7925	.7935	.7945	.7955	.7965	.7975	.7985	.7995	.8005
66	.7925	.7935	.7945	.7955	.7965	.7975	.7985	.7995	.8005	.8015
68	.7930	.7940	7950	.7960	.7970	.7980	.7990	.8000	.8010	.8020
70	.7940	.7950	.7960	.7970	.7980	.7990	.8000	.8010	.8020	.8030
72	.7945	.7955	.7965	.7975	.7985	.7995	.8005	.8015	.8025	.8035
74	.7955	.7965	.7975	.7985	7995	.8005	.8015	.8025	.8035	.8045
76	.7965	.7975	.7985	.7995	.8005	.8015	.8020	.8030	.8040	.8050
78	.7970	.7980	.7990	.8000	.8010	.8020	.8030	.8040	.8050	.8060
80	.798	.799	.800	.801	.802	.803	.804	.805	.806	.807
82	.798	.799	.800	.801	.802	.803	.804	.805	.806	.807
84	.799	.800	.801	.802	.803	.804	.805	.806	.807	.808
86	.800	.801	.802	.803	.804	.805	.806	.807	.808	.809
88	.801	.802	.803	.804	.805	.806	.807	.808	.809	.810
90	.802	.803	.804	.805	.806	.807	.808	.809	.810	.811
92	.802	803	.804	.805	.806	.807	.808	.809	.810	.811
94	803	.804	.805	.806	.807	.808	.809	.810	.811	.812
96	.804	.805	.806	.807	.808	.809	.810	.811	.812	.813
98	.805	.806	.807	.808	.809	.810	.811	.812	.813	.814
100	.805	.806	.807	.808	.809	.810	.811	.812	.813	.814
102	.806	.807	.808	.809	.810	.811	.812	.813	.814	.815
104	.807	.808	.809	.810	.811	.812	.813	.814	.815	.816
106	.808	.809	.810	.811	.812	.813	.813	.814	.815	.816
108	.808	.809	.810	.811	.812	.813	.814	.815	.816	.817
110	.809	.810	.811	.812	.813	.814	.815	.816	.817	.818
112	.810	.811	.812	.813	.814	.815	.816	.817	.818	.819
114	.811	.812	.813	.814	.815	.816	.816	.817	.818	.819
116	.811	.812	.813	.814	.815	.816	.817	.818	.819	.820
118	.812	.813	.814	.815	.816	.817	.818	.819	.820	.821
120	.813	.814	.815	.816	.817	.818	.819	.820	.821	.822

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.800	0.801	0.802	0.803	0.804	0.805	0.806	0.807	0.808	0.809
	Corresponding specific gravities at 60°/60° F									
30	0.788	0.789	0.790	0.791	0.792	0.793	0.794	0.795	0.796	0.797
32	.788	.789	.790	.791	.792	.793	.795	.796	.797	.798
34	.789	.790	.791	.792	.793	.794	.795	.796	.797	.798
36	.790	.791	.792	.793	794	.795	.796	.797	.798	.799
38	.791	.792	.793	.794	.795	.796	.797	.798	.799	.800
40	.7920	.7930	.7940	.7450	.7960	.7970	.7980	.7990	.8000	.8010
42	.7930	.7940	.7950	.7960	.7970	.7980	.7990	.8000	.8010	.8020
44	.7935	.7945	.7955	.7965	.7975	.7985	.7995	.8005	.8015	.8025
46	.7945	.7955	.7965	7975	.7985	.7995	.8005	.8015	.8025	.8035
48	.7950	.7960	.7970	.7980	.7990	.8000	.8010	.8020	.8030	.8040
50	.7960	.7970	.7980	.7990	.8000	.8010	.8020	.8030	.8040	.8050
52	.7970	.7980	.7990	.8000	.8010	.8020	.8030	.8040	.8050	.8060
54	.7975	.7985	.7995	.8005	.8015	.8025	.8035	.8045	.8055	.8065
56	.7985	.7995	.8005	.8015	.8025	.8035	.8045	.8055	.8065	.8075
58	.7995	.8005	.8015	.8025	.8035	.8045	.8055	.8065	.8075	.8085
60	.8000	.8010	.8020	.8030	.8040	.8050	.8060	.8070	.8080	.8090
62	.8005	.8015	.8025	.8035	.8045	.8055	.8065	.8075	.8085	.8095
64	.8015	.8025	.8035	.8045	.8055	.8065	.8075	.8085	.8095	.8105
66	.8025	.8035	.8045	.8055	.8065	.8075	.8085	.8095	.8105	.8115
68	.8030	.8040	.8050	.8060	.8070	.8080	.8090	.8100	.8110	.8120
70	.8040	.8050	.8060	.8070	.8080	.8090	.8100	.8110	.8120	.8130
72	.8045	.8055	.8065	.8075	.8085	.8095	.8105	.8115	.8125	.8135
74	.8055	.8065	.8075	.8085	.8095	.8105	.8115	.8125	.8135	.8145
76	.8065	.8075	.8085	.8095	.8105	.8115	.8120	.8130	.8140	.8150
78	.8070	.8080	.8090	.8100	.8110	.8120	.8130	.8140	.8150	.8160
80	.808	.809	.810	.811	.812	.813	.813	.814	.815	.816
82	.808	.809	.810	.811	.812	.813	.814	.815	.816	.817
84	.809	.810	.811	.812	.813	.814	.815	.816	.817	.818
86	.810	.811	.812	.813	.814	.815	.816	.817	.818	.819
88	.811	.812	.813	.814	.815	.816	.816	.817	.818	.819
90	.812	.813	.814	.815	.816	.817	.817	.818	.819	.820
92	.812	.813	.814	.815	.816	.817	.818	.819	.820	.821
94	.813	.814	.815	.816	.817	.818	.819	.820	.821	.822
96	.814	.815	.816	.817	.818	.819	.819	.820	.821	.822
98	.815	.816	.817	.818	.819	.820	.820	.821	.822	.823
100	.815	.816	.817	.818	.819	.820	.821	.822	.823	.824
102	.816	.817	.818	.819	.820	.821	.822	.823	.824	.825
104	.817	.818	.819	.820	.821	.822	.822	.823	.824	.825
106	.817	.818	.819	.820	821	.822	.823	.824	.825	.826
108	.818	.819	.820	.821	.822	.823	.824	.825	.826	.827
110	.819	.820	.821	.822	.823	.824	.825	.826	.827	.828
112	.820	.821	.822	.823	.824	.825	.825	.826	.827	.828
114	.820	.821	.822	.823	.824	.825	.826	.827	.828	.829
116	.821	.822	.823	.824	.825	.826	.827	.828	.829	.830
118	.822	.823	.824	.825	.826	.827	.828	.829	.830	.831
120	.823	.824	.825	.826	.827	.828	.828	.829	.830	.831

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.810	.811	0.812	0.813	0.814	0.815	0.816	0.817	0.818	0.819
	Corresponding specific gravities at 60°/60° F									
30	0.798	0.799	0.800	0.801	0.802	0.803	0.804	0.805	0.806	0.807
32	.799	.800	.801	.802	.803	.804	.805	.806	.807	.808
34	.799	.800	.801	.802	.803	.804	.806	.807	.808	.809
36	.800	.801	.802	.803	.804	.805	.807	.808	.809	.810
38	.801	.802	.803	.804	.805	.806	.808	.809	.810	.811
40	.8020	.8030	.8040	.8050	.8060	.8070	.8085	.8095	.8105	.8115
42	.8030	.8040	.8050	.8060	.8070	.8080	.8090	.8100	.8110	.8120
44	.8035	.8045	.8055	.8065	.8075	.8085	.8100	.8110	.8120	.8130
46	.8045	.8055	.8065	.8075	.8085	.8095	.8105	.8115	.8125	.8135
48	.8050	.8060	.8070	.8080	.8090	.8100	.8115	.8125	.8135	.8145
50	.8060	.8070	.8080	.8090	.8100	.8110	.8120	.8130	.8140	.8150
52	.8070	.8080	.8090	.8100	.8110	.8120	.8130	.8140	.8150	.8160
54	.8075	.8085	.8095	.8105	.8115	.8125	.8135	.8145	.8155	.8165
56	.8085	.8095	.8105	.8115	.8125	.8135	.8145	.8155	.8165	.8175
58	.8095	.8105	.8115	.8125	.8135	.8145	.8155	.8165	.8175	.8185
60	.8100	.8110	.8120	.8130	.8140	.8150	.8160	.8170	.8180	.8190
62	.8105	.8115	.8125	.8135	.8145	.8155	.8165	.8175	.8185	.8195
64	.8115	.8125	.8135	.8145	.8155	.8165	.8175	.8185	.8195	.8205
66	.8125	.8135	.8145	.8155	.8165	.8175	.8180	.8190	.8200	.8210
68	.8130	.8140	.8150	.8160	.8170	.8180	.8190	.8200	.8210	.8220
70	.8140	.8150	.8160	.8170	.8180	.8190	.8200	.8210	.8220	.8230
72	.8145	.8155	.8165	.8175	.8185	.8195	.8205	.8215	.8225	.8235
74	.8155	.8165	.8175	.8185	.8195	.8205	.8215	.8225	.8235	.8245
76	.8160	.8170	.8180	.8190	.8200	.8210	.8220	.8230	.8240	.8250
78	.8170	.8180	.8190	.8200	.8210	.8220	.8230	.8240	.8250	.8260
80	.817	.818	.819	.820	.821	.822	.823	.824	.825	.826
82	.818	.819	.820	.821	.822	.823	.824	.825	.826	.827
84	.819	.820	.821	.822	.823	.824	.825	.826	.827	.828
86	.820	.821	.822	.823	.824	.825	.826	.827	.828	.829
88	.820	.821	.822	.823	.824	.825	.826	.827	.828	.829
90	.821	.822	.823	.824	.825	.826	.827	.828	.829	.830
92	.822	.823	.824	.825	.826	.827	.828	.829	.830	.831
94	.823	.824	.825	.826	.827	.828	.828	.829	.830	.831
96	.823	.824	.825	.826	.827	.828	.829	.830	.831	.832
98	.824	.825	.826	.827	.828	.829	.830	.831	.832	.833
100	.825	.826	.827	.828	.829	.830	.831	.832	.833	.834
102	.826	.827	.828	.829	.830	.831	.831	.832	.833	.834
104	.826	.827	.828	.829	.830	.831	.832	.833	.834	.835
106	.827	.828	.829	.830	.831	.832	.833	.834	.835	.836
108	.828	.829	.830	.831	.832	.833	.834	.835	.836	.837
110	.829	.830	.831	.832	.833	.834	.834	.835	.836	.837
112	.829	.830	.831	.832	.833	.834	.835	.836	.837	.838
114	.830	.831	.832	.833	.834	.835	.836	.837	.838	.839
116	.831	.832	.833	.834	.835	.836	.836	.837	.838	.839
118	.832	.833	.834	.835	.836	.837	.837	.838	.839	.840
120	.832	.833	.834	.835	.836	.837	.838	.839	.840	.841

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.820	0.821	0.822	0.823	0.824	0.825	0.826	0.827	0.828	0.829
	Corresponding specific gravities at 60°/60° F									
30	0.808	0.809	0.810	0.811	0.812	0.813	0.814	0.815	0.816	0.817
32	.809	.810	.811	.812	.813	.814	.815	.816	.817	.818
34	.810	.811	.812	.813	.814	.815	.816	.817	.818	.819
36	.811	.812	.813	.814	.815	.816	.817	.818	.819	.820
38	.812	.813	.814	.815	.816	.817	.818	.819	.820	.821
40	.8125	.8135	.8145	.8155	.8165	.8175	.8185	.8195	.8205	.8215
42	.8130	.8140	.8150	.8160	.8170	.8180	.8190	.8200	.8210	.8220
44	.8140	.8150	.8160	.8170	.8180	.8190	.8200	.8210	.8220	.8230
46	.8145	.8155	.8165	.8175	.8185	.8195	.8205	.8215	.8225	.8235
48	.8155	.8165	.8175	.8185	.8195	.8205	.8215	.8225	.8235	.8245
50	.8160	.8170	.8180	.8190	.8200	.8210	.8220	.8230	.8240	.8250
52	.8170	.8180	.8190	.8200	.8210	.8220	.8230	.8240	.8250	.8260
54	.8175	.8185	.8195	.8205	.8215	.8225	.8240	.8250	.8260	.8270
56	.8185	.8195	.8205	.8215	.8225	.8235	.8245	.8255	.8265	.8275
58	.8195	.8205	.8215	.8225	.8235	.8245	.8255	.8265	.8275	.8285
60	.8200	.8210	.8220	.8230	.8240	.8250	.8260	.8270	.8280	.8290
62	.8205	.8215	.8225	.8235	.8245	.8255	.8265	.8275	.8285	.8295
64	.8215	.8225	.8235	.8245	.8255	.8265	.8275	.8285	.8295	.8305
66	.8220	.8230	.8240	.8250	.8260	.8270	.8280	.8290	.8300	.8310
68	.8230	.8240	.8250	.8260	.8270	.8280	.8290	.8300	.8310	.8320
70	.8240	.8250	.8260	.8270	.8280	.8290	.8300	.8310	.8320	.8330
72	.8245	.8255	.8265	.8275	.8285	.8295	.8305	.8315	.8325	.8335
74	.8255	.8265	.8275	.8285	.8295	.8305	.8315	.8325	.8335	.8345
76	.8260	.8270	.8280	.8290	.8300	.8310	.8320	.8330	.8340	.8350
78	.8270	.8280	.8290	.8300	.8310	.8320	.8330	.8340	.8350	.8360
80	.827	.828	.829	.830	.831	.832	.833	.834	.835	.836
82	.828	.829	.830	.931	.832	.833	.834	.835	.836	.837
84	.829	.830	.831	.832	.833	.834	.835	.836	.837	.838
86	.830	.831	.832	.833	.834	.835	.835	.836	.837	.838
88	.830	.831	.832	.833	.834	.835	.836	.837	.838	.839
90	.831	.832	.833	.834	.835	.836	.837	.838	.839	.840
92	.832	.833	.834	.835	.836	.837	.838	.839	.840	.841
94	.832	.833	.834	.835	.836	.837	.838	.839	.840	.841
96	.833	.834	.835	.836	.837	.838	.839	.840	.841	.842
98	.834	.835	.836	.837	.838	.839	.840	.841	.842	.843
100	.835	.836	.837	.838	.839	.840	.840	.841	.842	.843
102	.835	.836	.837	.838	.839	.840	.841	.842	.843	.844
104	.836	.837	.838	.839	.840	.841	.842	.843	.844	.845
106	.837	.838	.839	.840	.841	.842	.843	.844	.845	.846
108	.838	.839	.840	.841	.842	.843	.843	.844	.845	.846
110	.838	.839	.840	.841	.842	.843	.844	.845	.846	.847
112	.839	.840	.841	.842	.843	.844	.845	.846	.847	.848
114	.840	.841	.842	.843	.844	.845	.846	.847	.848	.849
116	.840	.841	.842	.843	.844	.845	.846	.847	.848	.849
118	.841	.842	.843	.844	.845	.846	.847	.848	.849	.850
120	.842	.843	.844	.845	.846	.847	.848	.849	.850	.851

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.830	0.831	0.832	0.833	0.834	0.835	0.836	0.837	0.838	0.839
	Corresponding specific gravities at 60°/60° F									
30	0.818	0.819	0.820	0.821	0.822	0.823	0.824	0.825	0.826	0.827
32	.819	.820	.821	.822	.823	.824	.825	.826	.827	.828
34	.820	.821	.822	.823	.824	.825	.826	.827	.828	.829
36	.821	.822	.823	.824	.825	.826	.827	.828	.829	.830
38	.822	.823	.824	.825	.826	.827	.828	.829	.830	.831
40	.8225	.8235	.8245	.8255	.8265	.8275	.8285	.8295	.8305	.8315
42	.8230	.8240	.8250	.8260	.8270	.8280	.8295	.8305	.8315	.8325
44	.8240	.8250	.8260	.8270	.8280	.8290	.8300	.8310	.8320	.8330
46	.8245	.8255	.8265	.8275	.8285	.8295	.8305	.8315	.8325	.8335
48	.8255	.8265	.8275	.8285	.8295	.8305	.8315	.8325	.3335	.8345
50	.8260	.8270	.8280	.8290	.8300	.8310	.8325	.8335	.8345	.8355
52	.8270	.8280	.8290	.8300	.8310	.8320	.8330	.8340	.8350	.8360
54	.8280	.8290	.8300	.8310	.8320	.8330	.8340	.8350	.8360	.8370
56	.8285	.8295	.8305	.8315	.8325	.8335	.8345	.8355	.8365	.8375
58	.8295	.8305	.8315	.8325	.8335	.8345	.8355	.8365	.8375	.8385
60	.8300	.8310	.8320	.8330	.8340	.8350	.8360	.8370	.8380	.8390
62	.8305	.8315	.8325	.8335	.8345	.8355	.8365	.8375	.8385	.8395
64	.8315	.8325	.8335	.8345	.8355	.8365	.8375	.8385	.8395	.8405
66	.8320	.8330	.8340	.8350	.8360	.8370	.8380	.8390	.8400	.8410
68	.8330	.8340	.8350	.8360	.8370	.8380	.8390	.8400	.8410	.8420
70	.8340	.8350	.8360	.8370	.8380	.8390	.8400	.8410	.8420	.8430
72	.8345	.8355	.8365	.8375	.8385	.8395	.8405	.8415	.8425	.8435
74	.8355	.8365	.8375	.8385	.8395	.8405	.8415	.8425	.8435	.8445
76	.8360	.8370	.8380	.8390	.8400	.8410	.8420	.8430	.8440	.8450
78	.8370	.8380	.8390	.8400	.8410	.8420	.8430	.8440	.8450	.8460
80	.837	.838	.839	.840	.841	.842	.843	.844	.845	.846
82	.838	.839	.840	.841	.842	.843	.844	.845	.846	.847
84	.839	.840	.841	.842	.843	.844	.845	.846	.847	.848
86	.839	.840	.841	.842	.843	.844	.845	.846	.847	.848
88	.840	.841	.842	.843	.844	.845	.846	.847	.848	.849
90	.841	.842	.843	.844	.845	.846	.847	.848	.849	.850
92	.842	.843	.844	.845	.846	.847	.848	.849	.850	.851
94	.842	.843	.844	.845	.846	.847	.848	.849	.850	.851
96	.843	.844	.845	.846	.847	.848	.849	.850	.851	.852
98	.844	.845	.846	.847	.848	.849	.850	.851	.852	.853
100	.844	.845	.846	.847	.848	.849	.850	.851	.852	.853
102	.845	.846	.847	.848	.849	.850	.851	.852	.853	.854
104	.846	.847	.848	.849	.850	.851	.852	.853	.854	.855
106	.847	.848	.849	.850	.851	.852	.853	.854	.855	.856
108	.847	.848	.849	.850	.851	.852	.853	.854	.855	.856
110	.848	.849	.850	.851	.852	.853	.854	.855	.856	.857
112	.849	.850	.851	.852	.853	.854	.855	.856	.857	.858
114	.850	.851	.852	.853	.854	.855	.855	.856	.857	.858
116	.850	.851	.852	.853	.854	.855	.856	.857	.858	.859
118	.851	.852	.853	.854	.855	.856	.857	.858	.859	.860
120	.852	.853	.854	.855	.856	.857	.858	.859	.860	.861

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.840	0.841	0.842	0.843	0.844	0.845	0.846	0.847	0.848	0.849
	Corresponding specific gravities at 60°/60° F									
30	0.828	0.829	0.830	0.831	0.832	0.833	0.835	0.836	0.837	0.838
32	.829	.830	.831	.832	.833	.834	.835	.836	.837	.838
34	.830	.831	.832	.833	.834	.835	.836	.837	.838	.839
36	.831	.832	.833	.834	.835	.836	.837	.838	.839	.840
38	.832	.833	.834	.835	.836	.837	.838	.839	.840	.841
40	.8325	.8335	.8345	.8355	.8365	.8375	.8385	.8395	.8405	.8415
42	.8335	.8345	.8355	.8365	.8375	.8385	.8395	.8405	.8415	.8425
44	.8340	.8350	.8360	.8370	.8380	.8390	.8400	.8410	.8420	.8430
46	.8345	.8355	.8365	.8375	.8385	.8395	.8410	.8420	.8430	.8440
48	.8355	.8365	.8375	.8385	.8395	.8405	.8415	.8425	.8435	.8445
50	.8365	.8375	.8385	.8395	.8405	.8415	.8425	.8435	.8445	.8455
52	.8370	.8380	.8390	.8400	.8410	.8420	.8430	.8440	.8450	.8460
54	.8380	.8390	.8400	.8410	.8420	.8430	.8440	.8450	.8460	.8470
56	.8385	.8395	.8405	.8415	.8425	.8435	.8445	.8455	.8465	.8475
58	.8395	.8405	.8415	.8425	.8435	.8445	.8455	.8465	.8475	.8485
60	.8400	.8410	.8420	.8430	.8440	.8450	.8460	.8470	.8480	.8490
62	.8405	.8415	.8425	.8435	.8445	.8455	.8465	.8475	.8485	.8495
64	.8415	.8425	.8435	.8445	.8455	.8465	.8475	.8485	.8495	.8505
66	.8420	.8430	.8440	.8450	.8460	.8470	.8480	.8490	.8500	.8510
68	.8430	.8440	.8450	.8460	.8470	.8480	.8490	.8500	.8510	.8520
70	.8440	.8450	.8460	.8470	.8480	.8490	.8500	.8510	.8520	.8530
72	.8445	.8455	.8465	.8475	.8485	.8495	.8505	.8515	.8525	.8535
74	.8455	.8465	.8475	.8485	.8495	.8505	.8510	.8520	.8530	.8540
76	.8460	.8470	.8480	.8490	.8500	.8510	.8520	.8530	.8540	.8550
78	.8470	.8480	.8490	.8500	.8510	.8520	.8525	.8535	.8545	.8555
80	.847	.848	.849	.850	.851	.852	.853	.854	.855	.856
82	.848	.849	.850	.851	.852	.853	.854	.855	.856	.857
84	.849	.850	.851	.852	.853	.854	.855	.856	.857	.858
86	.849	.850	.851	.852	.853	.854	.855	.856	.857	.858
88	.850	.851	.852	.853	.854	.855	.856	.857	.858	.859
90	.851	.852	.853	.854	.855	.856	.857	.858	.859	.860
92	.852	.853	.854	.855	.856	.857	.857	.858	.859	.860
94	.852	.853	.854	.855	.856	.857	.858	.859	.860	.861
96	.853	.854	.855	.856	.857	.858	.859	.860	.861	.862
98	.854	.855	.856	.857	.858	.859	.860	.861	.862	.863
100	.854	.855	.856	.857	.858	.859	.860	.861	.862	.863
102	.855	.856	.857	.858	.859	.860	.861	.862	.863	.864
104	.856	.857	.858	.859	.860	.861	.862	.863	.864	.865
106	.857	.858	.859	.860	.861	.862	.862	.863	.864	.865
108	.857	.858	.859	.860	.861	.862	.863	.864	.865	.866
110	.858	.859	.860	.861	.862	.863	.864	.865	.866	.867
112	.859	.860	.861	.862	.863	.864	.865	.866	.867	.868
114	.859	.860	.861	.862	.863	.864	.865	.866	.867	.868
116	.860	.861	.862	.863	.864	.865	.866	.867	.868	.869
118	.861	.862	.863	.864	.865	.866	.867	.868	.869	.870
120	.862	.863	.864	.865	.866	.867	.868	.869	.870	.871

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.850	0.851	0.852	0.853	0.854	0.855	0.856	0.857	0.858	0.859
	Corresponding specific gravities at 60°/60° F									
30	0.839	0.840	0.841	0.842	0.843	0.844	0.845	0.846	0.847	0.848
32	.839	.840	.841	.842	.843	.844	.845	.846	.847	.848
34	.840	.841	.842	.843	.844	.845	.846	.847	.848	.849
36	.841	.842	.843	.844	.845	.846	.847	.848	.849	.850
38	.842	.843	.844	.845	.846	.847	.848	.849	.850	.851
40	.8425	.8435	.8445	.8455	.8465	.8475	.8485	.8495	.8505	.8515
42	.8435	.8445	.8455	.8465	.8475	.8485	.8495	.8505	.8515	.8525
44	.8440	.8450	.8460	.8470	.8480	.8490	.8500	.8510	.8520	.8530
46	.8450	.8460	.8470	.8480	.8490	.8500	.8510	.8520	.8530	.8540
48	.8455	.8465	.8475	.8485	.8495	.8505	.8515	.8525	.8535	.8545
50	.8465	.8475	.8485	.8495	.8505	.8515	.8525	.8535	.8545	.8555
52	.8470	.8480	.8490	.8500	.8510	.8520	.8530	.8540	.8550	.8560
54	.8480	.8490	.8500	.8510	.8520	.8530	.8540	.8550	.8560	.8570
56	.8485	.8495	.8505	.8515	.8525	.8535	.8545	.8555	.8565	.8575
58	.8495	.8505	.8515	.8525	.8535	.8545	.8555	.8565	.8575	.8585
60	.8500	.8510	.8520	.8530	.8540	.8550	.8560	.8570	.8580	.8590
62	.8505	.8515	.8525	.8535	.8545	.8555	.8565	.8575	.8585	.8595
64	.8515	.8525	.8535	.8545	.8555	.8565	.8575	.8585	.8595	.8605
66	.8520	.8530	.8540	.8550	.8560	.8570	.8580	.8590	.8600	.8610
68	.8530	.8540	.8550	.8560	.8570	.8580	.8590	.8600	.8610	.8620
70	.8540	.8550	.8560	.8570	.8580	.8590	.8595	.8605	.8615	.8625
72	.8545	.8555	.8565	.8575	.8585	.8595	.8605	.8615	.8625	.8635
74	.8550	.8560	.8570	.8580	.8590	.8600	.8610	.8620	.8630	.8640
76	.8560	.8570	.8580	.8590	.8600	.8610	.8620	.8630	.8640	.8650
78	.8565	.8575	.8585	.8595	.8605	.8615	.8625	.8635	.8645	.8655
80	.857	.858	.859	.860	.861	.862	.863	.864	.865	.866
82	.858	.859	.860	.861	.862	.863	.864	.865	.866	.867
84	.859	.860	.861	.862	.863	.864	.864	.865	.866	.867
86	.859	.860	.861	.862	.863	.864	.865	.866	.867	.868
88	.860	.861	.862	.863	.864	.865	.866	.867	.868	.869
90	.861	.862	.863	.864	.865	.866	.867	.868	.869	.870
92	.861	.862	.863	.864	.865	.866	.867	.868	.869	.870
94	.862	.863	.864	.865	.866	.867	.868	.869	.870	.871
96	.863	.864	.865	.866	.867	.868	.869	.870	.871	.872
98	.864	.865	.866	.867	.868	.869	.869	.870	.871	.872
100	.864	.865	.866	.867	.868	.869	.870	.871	.872	.873
102	.865	.866	.867	.868	.869	.870	.871	.872	.873	.874
104	.866	.867	.868	.869	.870	.871	.872	.873	.874	.875
106	.866	.867	.868	.869	.870	.871	.872	.873	.874	.875
108	.867	.868	.869	.870	.871	.872	.873	.874	.875	.876
110	.868	.869	.870	.871	.872	.873	.874	.875	.876	.877
112	.869	.870	.871	.872	.873	.874	.874	.875	.876	.877
114	.869	.870	.871	.872	.873	.874	.875	.876	.877	.878
116	.870	.871	.872	.873	.874	.875	.876	.877	.878	.879
118	.871	.872	.873	.874	.875	.876	.877	.878	.879	.880
120	.872	.873	.874	.875	.876	.877	.877	.878	.879	.880

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.860	0.861	0.862	0.863	0.864	0.865	0.866	0.867	0.868	0.869
	Corresponding specific gravities at 60°/60° F									
30	0.849	0.850	0.851	0.852	0.853	0.854	0.855	0.856	0.857	0.858
32	.849	.850	.851	.852	.853	.854	.856	.857	.858	.859
34	.850	.851	.852	.853	.854	.855	.856	.857	.858	.859
36	.851	.852	.853	.854	.855	.856	.857	.858	.859	.860
38	.852	.853	.854	.855	.856	.857	.858	.859	.860	.861
40	.8525	.8535	.8545	.8555	.8565	.8575	.8585	.8595	.8605	.8615
42	.8535	.8545	.8555	.8565	.8575	.8585	.8595	.8605	.8615	.8625
44	.8540	.8550	.8560	.8570	.8580	.8590	.8600	.8610	.8620	.8630
46	.8550	.8560	.8570	.8580	.8590	.8600	.8610	.8620	.8630	.8640
48	.8555	.8565	.8575	.8585	.8595	.8605	.8615	.8625	.8635	.8645
50	.8565	.8575	.8585	.8595	.8605	.8615	.8625	.8635	.8645	.8655
52	.8570	.8580	.8590	.8600	.8610	.8620	.8630	.8640	.8650	.8660
54	.8580	.8590	.8600	.8610	.8620	.8630	.8640	.8650	.8660	.8670
56	.8585	.8595	.8605	.8615	.8625	.8635	.8645	.8655	.8665	.8675
58	.8595	.8605	.8615	.8625	.8635	.8645	.8655	.8665	.8675	.8685
60	.8600	.8610	.8620	.8630	.8640	.8650	.8660	.8670	.8680	.8690
62	.8605	.8615	.8625	.8635	.8645	.8655	.8665	.8675	.8685	.8695
64	.8615	.8625	.8635	.8645	.8655	.8665	.8675	.8685	.8695	.8705
66	.8620	.8630	.8640	.8650	.8660	.8670	.8680	.8690	.8700	.8710
68	.8630	.8640	.8650	.8660	.8670	.8680	.8690	.8700	.8710	.8720
70	.8635	.8645	.8655	.8665	.8675	.8685	.8695	.8705	.8715	.8725
72	.8645	.8655	.8665	.8675	.8685	.8695	.8705	.8715	.8725	.8735
74	.8650	.8660	.8670	.8680	.8690	.8700	.8710	.8720	.8730	.8740
76	.8660	.8670	.8680	.8690	.8700	.8710	.8720	.8730	.8740	.8750
78	.8665	.8675	.8685	.8695	.8705	.8715	.8725	.8735	.8745	.8755
80	.867	.868	.869	.870	.871	.872	.873	.874	.875	.876
82	.868	.869	.870	.871	.872	.873	.874	.875	.876	.877
84	.868	.869	.870	.871	.872	.873	.874	.875	.876	.877
86	.869	.870	.871	.872	.873	.874	.875	.876	.877	.878
88	.870	.871	.872	.873	.874	.875	.876	.877	.878	.879
90	.871	.872	.873	.874	.875	.876	.877	.878	.879	.890
92	.871	.872	.873	.874	.875	.876	.877	.878	.879	.880
94	.872	.873	.874	.875	.876	.877	.878	.879	.880	.881
96	.873	.874	.875	.876	.877	.878	.879	.880	.881	.882
98	.873	.874	.875	.876	.877	.878	.879	.880	.881	.882
100	.874	.875	.876	.877	.878	.879	.880	.881	.882	.883
102	.875	.876	.877	.878	.879	.880	.881	.882	.883	.884
104	.876	.877	.878	.879	.880	.881	.882	.883	.884	.885
106	.876	.877	.878	.879	.880	.881	.882	.883	.884	.885
108	.877	.878	.879	.880	.881	.882	.883	.884	.885	.886
110	.878	.879	.880	.881	.882	.883	.884	.885	.886	.887
112	.878	.879	.880	.881	.882	.883	.884	.885	.886	.887
114	.879	.880	.881	.882	.883	.884	.885	.886	.887	.888
116	.880	.881	.882	.883	.884	.885	.886	.887	.888	.889
118	.881	.882	.883	.884	.885	.886	.886	.887	.888	.889
120	.881	.882	.883	.884	.885	.886	.887	.888	.889	.890

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.870	0.871	0.872	0.873	0.874	0.875	0.876	0.877	.0878	0.879
	Corresponding specific gravities at 60°/60° F									
30	0.859	0.860	0.861	0.862	0.863	0.864	0.865	0.866	0.867	0.868
32	.860	.861	.862	.863	.864	.865	.866	.867	.868	.869
34	.860	.861	.862	.863	.864	.865	.866	.867	.868	.869
36	.861	.862	.863	.864	.965	.866	.867	.868	.869	.870
38	.862	.863	.864	.865	.866	.867	.868	.869	.870	.871
40	.8625	.8635	.8645	.8655	.8665	.8675	.8690	.8700	.8710	.8720
42	.8635	.8645	.8655	.8665	.8675	.8685	.8695	.8705	.8715	.8725
44	.8640	.8650	.8660	.8670	.8680	.8690	.8700	.8710	.8720	.8730
46	.8650	.8660	.8670	.8680	.8690	.8700	.8710	.8720	.8730	.8740
48	.8655	.8665	.8675	.8685	.8695	.8705	.8715	.8725	.8735	.8745
50	.8665	.8675	.8685	.8695	.8705	.8715	.8725	.8735	.8745	.8755
52	.8670	.8680	.8690	.8700	.8710	.8720	.8730	.8740	.8750	.8760
54	.8680	.8690	.8700	.8710	.8720	.8730	.8740	.8750	.8760	.8770
56	.8685	.8695	.8705	.8715	.8725	.8735	.8745	.8755	.8765	.8775
58	.8695	.8705	.8715	8725	.8735	.8745	.8755	.8765	.8775	.8785
60	.8700	.8710	.8720	.8730	.8740	.8750	.8760	.8770	.8780	.8790
62	.8705	.8715	.8725	.8735	.8745	.8755	.8765	.8775	.8785	.8795
64	.8715	.8725	.8735	.8745	.8755	.8765	.8775	.8785	.8795	.8805
66	.8720	.8730	.8740	.8750	.8760	.8770	.8780	.8790	.8800	.8810
68	.8730	.8740	.8750	.8760	.8770	.8780	.8790	.8800	.8810	.8820
70	.8735	.8745	.8755	.8765	.8775	.8785	.8795	.8805	.8815	.8825
72	.8745	.8755	.8765	.8775	.8785	.8795	.8805	.8815	.8825	.8835
74	.8750	.8760	.8770	.8780	.8790	.8800	.8810	.8820	.8830	.8840
76	.8760	.8770	.8780	.8790	.8800	.8810	.8820	.8830	.8840	.8850
78	.8765	.8775	.8785	.8795	.8805	.8815	.8825	.8835	.8845	.8855
80	.877	.878	.879	.880	.881	.882	.883	.884	.885	.886
82	.878	.879	.880	.881	.882	.883	.884	.885	.886	.887
84	.878	.879	.880	.881	.882	.883	.884	.885	.886	.887
86	.879	.880	.881	.882	.883	.884	.885	.886	.887	.888
88	.880	.881	.882	.883	.884	.885	.886	.887	.888	.889
90	.881	.882	.883	.884	.885	.886	.887	.888	.889	.890
92	.881	.882	.883	.884	.885	.886	.887	.888	.889	.890
94	.882	.883	.884	.885	.886	.887	.888	.889	.890	.891
96	.883	.884	.885	.886	.887	.888	.889	.890	.891	.892
98	.883	.884	.885	.886	.887	.888	.889	.890	.891	.892
100	.884	.885	.886	.887	.888	.889	.890	.891	.892	.893
102	.885	.886	.887	.888	.889	.890	.891	.892	.893	.894
104	.886	.887	.888	.889	.890	.891	.891	.892	.893	.894
106	.886	.887	.888	.889	.890	.891	.892	.893	.894	.895
108	.887	.888	.889	.890	.891	.892	.893	.894	.895	.896
110	.888	.889	.890	.891	.892	.893	.894	.895	.896	.897
112	.888	.889	.890	.891	.892	.893	.894	.895	.896	.897
114	.889	.890	.891	.892	.893	.894	.895	.896	.897	.898
116	.890	.891	.892	.893	.894	.895	.896	.897	.898	.899
118	.890	.891	.892	.893	.894	.895	.896	.897	.898	.899
120	.891	.892	.893	.894	.895	.896	.897	.898	.899	.900

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.880	0.881	0.882	0.883	0.884	0.885	0.886	0.887	0.888	0.889
	Corresponding specific gravities at 60°/60° F									
30	0.869	0.870	0.871	0.872	0.873	0.874	0.875	0.876	0.877	0.878
32	.870	.871	.872	.873	.874	.875	.876	.877	.878	.879
34	.870	.871	.872	.873	.874	.875	.876	.877	.878	.879
36	.871	.872	.873	.874	.875	.876	.877	.878	.879	.880
38	.872	.873	.874	.875	.876	.877	.878	.879	.880	.881
40	.8730	.8740	.8750	.8760	.8770	.8780	.8790	.8800	.8810	.8820
42	.8735	.8745	.8755	.8765	.8775	.8785	.8795	.8805	.8815	.8825
44	.8740	.8750	.8760	.8770	.8780	.8790	.8800	.8810	.8820	.8830
46	.8750	.8760	.8770	.8780	.8790	.8800	.8810	.8820	.8830	.8840
48	.8755	.8765	.8775	.8785	.8795	.8805	.8815	.8825	.8835	.8845
50	.8765	.8775	.8785	.8795	.8805	.8815	.8825	.8835	.8845	.8855
52	.8770	.8780	.8790	.8800	.8810	.8820	.8830	.8840	.8850	.8860
54	.8780	.8790	.8800	.8810	.8820	.8830	.8840	.8850	.8860	.8870
56	.8785	.8795	.8805	.8815	.8825	.8835	.8845	.8855	.8865	.8875
58	.8795	.8805	.8815	.8825	.8835	.8845	.8855	.8865	.8875	.8885
60	.8800	.8810	.8820	.8830	.8840	.8850	.8860	.8870	.8880	.8890
62	.8805	.8815	.8825	.8835	.8845	.8855	.8865	.8875	.8885	.8895
64	.8815	.8825	.8835	.8845	.8855	.8865	.8875	.8885	.8895	.8905
66	.8820	.8830	.8840	.8850	.8860	.8870	.8880	.8890	.8900	.8910
68	.8830	.8840	.8850	.8860	.8870	.8880	.8890	.8900	.8910	.8920
70	.8835	.8845	.8855	.8865	.8875	.8885	.8895	.8905	.8915	.8925
72	.8845	.8855	.8865	.8875	.8885	.8895	.8900	.8910	.8920	.8930
74	.8850	.8860	.8870	.8880	.8890	.8900	.8910	.8920	.8930	.8940
76	.8860	.8870	.8880	.8890	.8900	.8910	.8915	.8925	.8935	.8945
78	.8865	.8875	.8885	.8895	.8905	.8915	.8925	.8935	.8945	.8955
80	.887	.888	.889	.890	.891	.892	.893	.894	.895	.896
82	.888	.889	.890	.891	.892	.893	.894	.895	.896	.897
84	.888	.889	.890	.891	.892	.893	.894	.895	.896	.897
86	.889	.890	.891	.892	.893	.894	.895	.896	.897	.898
88	.890	.891	.892	.893	.894	.895	.896	.897	.898	.899
90	.891	.892	.893	.894	.895	.896	.896	.897	.898	.899
92	.891	.892	.893	.894	.895	.896	.897	.898	.899	.900
94	.892	.893	.894	.895	.896	.897	.898	.899	.900	.901
96	.893	.894	.895	.896	.897	.898	.899	.900	.901	.902
98	.893	.894	.895	.896	.897	.898	.899	.900	.901	.902
100	.894	.895	.896	.897	.898	.899	.900	.901	.902	.903
102	.895	.896	.897	.898	.899	.900	.901	.902	.903	.904
104	.895	.896	.897	.898	.899	.900	.901	.902	.903	.904
106	.896	.897	.898	.899	.900	.901	.902	.903	.904	.905
108	.897	.898	.899	.900	.901	.902	.903	.904	.905	.906
110	.898	.899	.900	.901	.902	.903	.903	.904	.905	.906
112	.898	.899	.900	.901	.902	.903	.904	.905	.906	.907
114	.899	.900	.901	.902	.903	.904	.905	.906	.907	.908
116	.900	.901	.902	.903	.904	.905	.905	.906	.907	.908
118	.900	.901	.902	.903	.904	.905	.906	.907	.908	.909
120	.901	.902	.903	.904	.905	.906	.907	.908	.909	.910

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.890	0.891	0.892	0.893	0.894	0.895	0.896	0.897	0.898	0.899
	Corresponding specific gravities at 60°/60° F									
30	0.879	0.880	0.881	0.882	0.883	0.884	0.885	0.886	0.887	0.888
32	.880	.881	.882	.883	.884	.885	.886	.887	.888	889
34	.880	.881	.882	.883	.884	.885	.886	.887	.888	889
36	.881	.882	.883	.884	.885	.886	.887	.888	.889	.890
38	.882	.883	.884	.885	.886	.887	.888	.889	.890	.891
40	.8830	.8840	.8850	.8860	.8870	.8880	.8890	.8900	.8910	.8920
72	.8940	.8950	.8960	.8970	.8980	.8990	.9000	.9010	.9020	.9030
44	.8840	.8850	.8860	.8870	.8880	.8890	.8900	.8010	.8920	.2930
46	.8850	.8860	.8870	.8880	.8890	.8900	.8910	.8920	.8930	.8940
48	.8855	.8865	.8875	.8885	.8895	.8905	.8915	.8925	.8935	.8945
50	.8865	8875	.8885	.8895	.8905	.8915	.8925	.8935	.8945	.8955
52	.8870	.8880	.8890	.8900	.8910	.8920	.8930	.8940	.8950	.8960
54	.8880	.8890	.8900	.8910	.8920	.8930	.8940	.8950	.8960	.8970
56	.8885	.8895	.8905	.8915	.8925	.8935	.8945	.8955	.8965	.8975
58	.8895	.8905	.8915	.8925	.8935	.8945	.8955	.8965	.8975	.8985
60	.8900	.8910	.8920	.8930	.8940	.8950	.8960	.8970	.8980	.8990
62	.8905	.8915	.8925	.8935	.8945	.8955	.8965	.8975	.8985	.8995
64	.8915	.8925	.8935	.8945	.8955	.8965	.8975	.8985	.8995	.9005
66	.8920	.8930	.8940	.8950	.8960	.8970	.8980	.8990	.9000	.9010
68	.8930	.8940	.8950	.8960	.8970	.8980	.8990	.9000	.9010	.9020
70	.8935	.8945	.8955	.8965	.8975	.8985	.8995	.9005	.9015	.9025
72	.8940	.8950	.8960	.8970	.8980	.8990	.9000	.9010	.9020	.9030
74	.8950	.8960	.8970	.8980	.8990	.9000	.9010	.9020	.9030	.9040
76	.8955	.8965	.8975	.8985	.8995	.9005	.9015	.9025	.9035	.9045
78	.8965	.8975	.8985	.8995	.9005	.9015	.9025	.9035	.9045	.9055
80	.897	.898	.899	.900	.901	.902	.903	.904	.905	.906
82	.898	.899	.900	.901	.902	.903	.903	.904	.905	.906
84	.898	.899	.900	.901	.902	.903	.904	.905	.906	.907
86	.899	.900	.901	.902	.903	.904	.905	.906	.907	.908
88	.900	.901	.902	.903	.904	.905	.906	.907	.908	.909
90	.900	.901	.902	.903	.904	.905	.906	.907	.908	.909
92	.901	.902	.903	.904	.905	.906	.907	.908	.909	.910
94	.902	.903	.904	.905	.906	.907	.908	.909	.910	.911
96	.903	.904	.905	.906	.907	.908	.909	.910	.911	.912
98	.903	.904	.905	.906	.907	.908	.909	.910	.911	.912
100	.904	.905	.906	.907	.908	.909	.910	.911	.912	.913
102	.905	.906	.907	.908	.909	.910	.911	.912	.913	.914
104	.905	.906	.907	.908	.909	.910	.911	.912	.913	.914
106	.906	.907	.908	.909	.910	.911	.912	.913	.914	.915
108	.907	.908	.909	.910	.911	.912	.913	.914	.915	.916
110	.907	.908	.909	.910	.911	.912	.913	.914	.915	.916
112	.908	.909	.910	.911	.912	.913	.914	.915	.916	.917
114	.909	.910	.911	.912	.913	.914	.915	.916	.917	.918
116	.909	.910	.911	.912	.913	.914	.915	.916	.917	.918
118	.910	.911	.912	.913	.914	.915	.916	.917	.918	.919
120	.911	.912	.913	.914	.915	.916	.917	.918	.919	.920

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.900	0.901	9.902	9.903	0.904	0.905	0.906	0.907	0.908	0.909
	Corresponding specific gravities at 60°/60° F									
30	0.889	0.890	0.891	0.892	0.893	0.894	0.895	0.896	0.897	0.898
32	.890	.891	.892	.893	.894	.895	.896	.897	.898	.899
34	.890	.891	.892	.893	894	.895	.896	.897	.898	.899
36	.891	.892	.893	.894	.895	.896	.897	.898	.899	.900
38	.892	.893	.894	.895	.896	.897	.898	.899	.900	.901
40	.8930	.8940	.8950	.8960	.8970	.8980	.8990	.9000	.9010	.9020
42	.8935	.8945	.8955	.8965	.8975	.8985	.8995	.9005	.9015	.9025
44	.8940	.8950	.8960	.8970	.8980	.8990	.9005	.9015	.9025	.9035
46	.8950	.8960	.8970	.8980	.8990	.9000	.9010	.9020	.9030	.9040
48	.8955	.8965	.8975	.8985	.8995	.9005	.9015	9025	.9035	.9045
50	.8965	.8975	.8985	.8995	.9005	.9015	.9025	.9035	.9045	.9055
52	.8970	.8980	.8990	.9000	.9010	.9020	.9030	.9040	.9050	.9060
54	.8980	.8990	.9000	.9010	.9020	.9030	.9040	.9050	.9060	.9070
56	.8985	.8995	.9005	.9015	.9025	.9035	.9045	.9055	.9065	.9075
58	.8995	.9005	.9015	.9025	.9035	.9045	.9055	.9065	.9075	.9085
60	.9000	.9010	.9020	.9030	.9040	.9050	.9060	.9070	.9080	.9090
62	.9005	.9015	.9025	.9035	.9045	.9055	.9065	9075	.9085	.9095
64	.9015	.9025	.9035	.9045	.9055	.9065	.9075	.9085	.9095	.9105
66	.9020	.9030	.9040	.9050	.9060	.9070	.9080	.9090	.9100	.9110
68	.9030	.9040	.9050	.9060	.9070	.9080	.9090	.9100	.9110	.9120
70	.9035	.9045	.9055	.9065	.9075	.9085	.9095	.9105	.9115	.9125
72	.9040	.9050	.9060	.9070	.9080	.9090	.9100	.9110	.9120	.9130
74	.9050	.9060	.9070	.9080	.9090	.9100	.9110	.9120	.9130	.9140
76	.9055	.9065	.9075	.9085	.9095	.9105	.9115	.9125	.9135	.9145
78	.9065	.9075	.9085	.9095	.9105	.9115	.9125	.9135	.9145	.9155
80	.907	.908	.909	.910	.911	.912	.913	.914	.915	.916
82	.907	.908	.909	.910	.911	.912	.913	.914	.915	.916
84	.908	.909	.910	.911	.912	.913	.914	.915	.916	.917
86	.909	.910	.911	.912	.913	.914	.915	.916	.917	.918
88	.910	.911	.912	.913	.914	.915	.916	.917	.918	.919
90	.910	.911	.912	.913	.914	.915	.916	.917	.918	.919
92	.911	.912	.913	.914	.915	.916	.917	.918	.919	.920
94	.912	.913	.914	.915	.916	.917	.918	.919	.920	.921
96	.913	.914	.915	.916	.917	.918	.918	.919	.920	.921
98	.913	.914	.915	.916	.917	.918	.919	.920	.921	.922
100	.914	.915	.916	.917	.918	.919	.920	.921	.922	.923
102	.915	.916	.917	.918	.919	.920	.921	.922	.923	.924
104	.915	.916	.917	.918	.919	.920	.921	.922	.923	.924
106	.916	.917	.918	.919	920	.921	.922	.923	.924	.925
108	.917	.918	.919	.920	.921	.922	.923	.924	.925	.926
110	.917	.918	.919	.920	.921	.922	.923	.924	.925	.926
112	.918	.919	.920	.921	.922	.923	.924	.925	.926	.927
114	.919	.920	.921	.922	.923	.924	.925	.926	.927	.928
116	.919	.920	.921	.922	.923	.924	.925	.926	.927	.928
118	.920	.921	922	.923	.924	.925	.926	.927	.928	.929
120	.921	.922	.923	.924	.925	.926	.927	.928	.929	.930

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.910	0.911	0.912	0.913	0.914	0.915	0.916	0.917	0.918	0.919
	Corresponding specific gravities at 60°/60° F									
30	0.899	0.900	0.901	0.902	0.903	0.904	0.905	0.906	0.907	0.908
32	.900	.901	.902	.903	.904	.905	.906	.907	.908	.909
34	.900	.901	.902	.903	.904	.905	.906	.907	.908	.909
36	.901	.902	.903	.904	.905	.906	.907	.908	.909	.910
38	.902	.903	.904	.905	.906	.907	.908	.909	.910	.911
40	.9030	.9040	.9050	.9060	.9070	.9080	.9090	.9100	.9110	.9120
42	.9035	.9045	.9055	.9065	.9075	.9085	.9095	.9105	.9115	.9125
44	.9045	.9055	.9065	.9075	.9085	.9095	.9105	.9115	.9125	.9135
46	.9050	.9060	.9070	.9080	.9090	.9100	.9110	.9120	.9130	.9140
48	.9055	.9065	.9075	9085	.9095	.9105	.9115	.9125	.9135	.9145
50	.9065	.9075	.9085	.9095	.9105	.9115	.9125	.9135	.9145	.9155
52	.9070	.9080	.9090	.9100	.9110	.9120	.9130	.9140	.9150	.9160
54	.9080	.9090	.9100	.9110	.9120	.9130	.9140	.9150	.9160	.9170
56	.9085	.9095	.9105	.9115	.9125	.9135	.9145	.9155	.9165	.9175
58	.9095	.9105	.9115	.9125	.9135	.9145	.9155	.9165	.9175	.9185
60	.9100	.9110	.9120	.9130	.9140	.9150	.9160	.9170	.9180	.9190
62	.9105	.9115	.9125	.9135	.9145	.9155	.9165	.9175	.9185	.9195
64	9115	.9125	.9135	.9145	.9155	.9165	.9175	.9185	.9195	.9205
66	9120	.9130	.9140	.9150	.9160	.9170	.9180	.9190	.9200	.9210
68	.9130	.9140	.9150	.9160	.9170	.9180	.9190	.9200	.9210	.9220
70	.9135	.9145	.9155	.9165	.9175	.9185	.9195	.9205	.9215	.9225
72	.9140	.9150	.9160	.9170	.9180	.9190	.9200	.9210	.9220	.9230
74	.9150	.9160	.9170	.9180	.9190	.9200	.9210	.9220	.9230	.9240
76	.9155	.9165	.9175	.9185	.9195	.9205	.9215	.9225	.9235	.9245
78	.9165	.9175	.9185	.9195	9205	.9215	.9225	.9235	.9245	.9255
80	.917	.918	.919	.920	.921	.922	.923	.924	.925	.926
82	.917	.918	.919	.920	.921	.922	.923	.924	.925	.926
84	.918	.919	.920	.921	.922	.923	.924	.925	.926	.927
86	.919	.920	.921	.922	.923	.924	.925	.926	.927	.928
88	.920	.921	.922	.923	.924	.925	.926	.927	.928	.929
90	.920	.921	.922	.923	.924	.925	.926	.927	.928	.929
92	.921	.922	.923	.924	.925	.926	.927	.928	.929	.930
94	.922	.923	.924	.925	.926	.927	.928	.929	.930	.931
96	.922	.923	.924	.925	.926	.927	.928	.929	.930	.931
98	.923	.924	.925	.926	.927	.928	.929	.930	.931	.932
100	.924	.925	.926	.927	.928	.929	.930	.931	.932	.933
102	.925	.926	.927	.928	.929	.930	.931	.932	.933	.934
104	.925	.926	.927	.928	.929	.930	.931	.932	.933	.934
106	.926	.927	.928	.929	.930	.931	.932	.933	.934	.935
108	.927	.928	.929	.930	.931	.932	.933	.934	.935	.936
110	.927	.928	.929	.930	.931	.932	.933	.934	.935	.936
112	.928	.929	.930	.931	.932	.933	.934	.935	.936	.937
114	.929	.930	.931	.932	.933	.934	.935	.936	.937	.938
116	.929	.930	.931	.932	.933	.934	.935	.936	.937	.938
118	.930	.931	.932	.933	.934	.935	.936	.937	.938	.939
120	.931	.932	.933	.934	.935	.936	.937	.938	.939	.940

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.920	0.921	0.922	0.923	0.924	0.925	0.926	0.927	0.928	0.929
	Corresponding specific gravities at 60°/60° F									
30	0.909	0.910	0.911	0.912	0.913	0.914	0.915	0.916	0.917	0.918
32	.910	.911	.912	.913	.914	.915	.916	.917	.918	.919
34	.910	.911	.912	.913	.914	.915	.916	.917	.918	.919
36	.911	.912	.913	.914	.915	.916	.917	.918	.919	.920
38	.912	.913	914	.915	.916	.917	.918	.919	.920	.921
40	.9130	.9140	.9150	.9160	.9170	.9180	.9190	.9200	.9210	.9220
42	9135	.9145	.9155	.9165	.9175	.9185	.9195	.9205	.9215	.9225
44	.9145	.9155	.9165	.9175	.9185	.9195	.9205	.9215	.9225	.9235
46	.9150	.9160	.9170	.9180	.9190	.9200	.9210	.9220	.9230	.9240
48	.9155	.9165	.9175	.9185	.9195	.9205	.9215	.9225	.9235	.9245
50	.9165	.9175	.9185	.9195	.9205	.9215	.9225	.9235	.9245	.9255
52	.9170	.9180	.9190	.9200	.9210	.9220	.9230	.9240	.9250	.9260
54	.9180	.9190	.9200	.9210	.9220	.9230	.9240	.9250	.9260	.9270
56	.9185	.9195	.9205	.9215	9225	.9235	.9245	.9255	.9265	.9275
58	.9195	.9205	.9215	.9225	.9235	.9245	.9255	.9265	.9275	.9285
60	.9200	.9210	.9220	.9230	.9240	.9250	.9260	.9270	.9280	.9290
62	.9205	.9215	.9225	.9235	.9245	.9255	.9265	.9275	.9285	.9295
64	.9215	.9225	.9235	.9245	.9255	.9265	.9275	.9285	.9295	.9305
66	.9220	.9230	.9240	.9250	.9260	.9270	.9280	.9290	.9300	.9310
68	.9230	.9240	.9250	.9260	.9270	.9280	.9290	.9300	.9310	.9320
70	.9235	.9245	.9255	.9265	.9275	.9285	.9295	.9305	.9315	.9325
72	.9240	.9250	.9260	.9270	.9280	.9290	.9300	.9310	.9320	.9330
74	.9250	.9260	.9270	.9280	.9290	.9300	.9310	.9320	.9330	.9340
76	.9255	.9265	.9275	.9285	.9295	.9305	.9315	.9325	.9335	.9345
78	.9265	.9275	.9285	.9295	9305	.9315	.9325	.9335	.9345	.9355
80	.927	.928	.929	.930	.931	.932	.933	.934	.935	.936
82	.927	.928	.929	.930	.931	.932	.933	.934	.935	.936
84	.928	.929	.930	.931	.932	.933	.934	.935	.936	.937
86	.929	.930	.931	.932	.933	.934	.935	.936	.937	.938
88	.930	.931	.932	.933	.934	.935	.936	.937	.938	.939
90	.930	.931	.932	.933	.934	.935	.936	.937	.938	.939
92	.931	.932	.933	.934	.935	.936	.937	.938	.939	.940
94	.932	933	.934	.935	.936	.937	.938	.939	.940	.941
96	.932	.933	.934	.935	.936	.937	.938	.939	.940	.941
98	.933	.934	.935	.936	.937	.938	.939	.940	.941	.942
100	.934	.935	.936	.937	.938	.939	.940	.941	.942	.943
102	.935	.936	.937	.938	.939	.940	.940	.941	.942	.943
104	.935	.936	.937	.938	.939	.940	.941	.942	.943	.944
106	.936	.937	.938	.939	.940	.941	.942	.943	.944	.945
108	.937	.938	.939	.940	.941	.942	.943	.944	.945	.946
110	.937	.938	.939	.940	.941	.942	.943	.944	.945	.946
112	.938	.939	.940	.941	.942	.943	.944	.945	.946	.947
114	.939	.940	.941	.942	.943	.944	.945	.946	.947	.948
116	.939	.940	.941	.942	.943	.944	.945	.946	.947	.948
118	.940	.941	.942	.943	.944	.945	.946	.947	.948	.949
120	.941	.942	.943	.944	.945	.946	.947	.948	.949	.950

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.930	0.931	0.932	0.933	0.934	0.935	0.936	0.937	0.938	0.939
	Corresponding specific gravities at 60°/60° F									
30	0.919	0.920	0.921	0.922	0.923	0.924	0.925	0.926	0.927	0.928
32	.920	.921	.922	.923	.924	.925	.926	.927	.928	.929
34	.920	.921	.922	.923	.924	.925	.926	.927	.928	.929
36	.921	.922	.923	.924	.925	.926	.927	.928	.929	.930
38	.922	.923	.924	.925	.926	.927	.928	.929	.930	.931
40	.9230	.9240	.9250	.9260	.9270	.9280	.9290	.9300	.9310	.9320
42	.9235	.9245	.9255	.9265	.9275	.9285	.9295	.9305	.9315	.9325
44	.9245	.9255	.9265	.9275	.9285	.9295	.9305	.9315	.9325	.9335
46	.9250	.9260	.9270	.9280	.9290	.9300	.9310	.9320	.9330	.9340
48	.9255	.9265	.9275	.9285	.9295	.9305	.9320	.9330	.9340	.9350
50	9265	.9275	.9285	.9295	.9305	.9315	.9325	.9335	.9315	.9355
52	.9270	.9280	.9290	.9300	.9310	.9320	.9330	.9340	.9350	.9360
54	.9280	.9290	.9300	.9310	.9320	.9330	.9340	.9350	.9360	.9370
56	.9285	9295	.9305	.9315	.9325	.9335	.9345	.9355	.9365	.9375
58	.9295	.9305	.9315	.9325	.9335	.9345	.9355	.9365	.9375	.9385
60	9300	.9310	.9320	.9330	.9340	.9350	.9360	.9370	.9380	.9390
62	.9305	.9315	.9325	.9335	.9345	.9355	.9365	.9375	.9385	.9395
64	.9315	.9325	.9335	.9345	.9355	.9365	.9375	.9385	.9395	.9405
66	.9320	.9330	.9340	.9350	.9360	.9370	.9380	.9390	.9400	.9410
68	.9330	.9340	.9350	.9360	.9370	.9380	.9390	.9400	.9410	.9420
70	.9335	.9345	.9355	.9365	.9375	.9385	.9395	.9405	.9415	.9425
72	.9340	.9350	.9360	.9370	.9380	.9390	.9400	.9410	.9420	.9430
74	.9350	.9360	.9370	.9380	.9390	.9400	.9410	.9120	.9430	.9440
76	.9355	.9365	9375	.9385	.9395	.9405	.9415	.9425	.9435	.9445
78	.9365	.9375	.9385	.9395	9405	.9415	.9425	.9435	.9445	.9455
80	.937	.938	.939	.940	.941	.942	.943	.944	.945	.946
82	.937	.938	.939	.940	.941	.942	.943	.944	.945	.946
84	.938	.939	.940	.941	.942	.943	.944	.945	.946	.947
86	.939	.940	.941	.942	.943	.944	.945	.946	.947	.948
88	.940	.941	.942	.943	.944	.945	.946	.947	.948	.949
90	.940	.941	.942	.943	.944	.945	.946	.947	.948	.949
92	.941	.942	.943	.944	.945	.946	.947	.948	.949	.950
94	.942	.943	.944	.945	.946	.947	.948	.949	.950	
96	.942	.943	.944	.945	.946	.947	.948	.949		
98	.943	.944	.945	.946	.947	.948	.949	.950		
100	.944	.945	.946	.947	.948	.949	.950			
102	.944	.945	.946	.947	.948	.950				
104	.945	.946	.947	.948	.949					
106	.946	.947	.948	.949	.950					
108	947	.948	.949	.950						
110	.947	.948	.949							
112	.948	.949	.950							
114	.949	.950								
116	.949									
118	.950									

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.940	0.941	0.942	0.943	0.944	0.945	0.946	0.947	0.948	0.949
	Corresponding specific gravities at 60°/60° F									
30	0.929	0.930	0.931	0.932	0.933	0.934	0.935	0.936	0.937	0.938
32	.930	.931	.932	.933	.934	.935	.936	.937	.938	.939
34	.930	.931	.932	.933	.934	.935	.936	.937	.938	.939
36	.931	.932	.933	.934	.935	.936	.937	.938	.939	.940
38	.932	.933	.934	.935	.936	.937	.938	.939	.940	.941
40	.9330	.9340	.9350	.9360	.9370	.9380	.9390	.9400	.9410	.9420
42	.9335	.9345	.9355	.9365	.9375	.9385	.9395	.9405	.9415	.9425
44	.9345	.9355	.9365	.9375	.9385	.9395	.9405	.9415	.9425	.9435
46	.9350	.9360	.9370	.9380	.9390	.9400	.9410	.9420	.9430	.9440
48	.9360	.9370	.9380	.9390	.9400	.9410	.9420	.9430	.9440	.9450
50	.9365	.9375	.9385	.9395	.9405	.9415	.9425	.9435	.9445	.9455
52	.9370	.9380	.9390	.9400	.9410	.9420	.9430	.9440	.9450	.9460
54	.9380	.9390	.9400	.9410	.9420	.9430	.9440	.9450	.9460	.9470
56	.9385	.9395	.9405	.9415	.9425	.9435	.9445	.9455	.9465	.9475
58	.9395	.9405	.9415	.9425	.9435	.9445	.9455	.9465	.9475	.9485
60	.9400	.9410	.9420	.9430	.9440	.9450	.9460	.9470	.9480	.9490
62	.9405	.9415	.9425	.9435	.9445	.9455	.9465	.9475	.9485	.9495
64	.9415	.9425	.9435	.9445	.9455	.9465	.9475	.9485	.9495	.9500
66	.9420	.9430	.9440	.9450	.9460	.9470	.9480	.9490	.9500	
68	.9430	.9440	.9450	.9460	.9470	.9480	.9490	.9500		
70	.9435	.9445	.9455	.9465	.9475	.9485	.9495			
72	.9440	.9450	.9460	.9470	.9480	.9490	.9500			
74	.9450	.9460	.9470	.9480	.9490	.9500				
76	.9455	.9465	.9475	.9485	.9495					
78	.9465	.9475	.9485	.9495	.9500					
80	.947	.948	.949	.950						
82	.947	.948	.949							
84	.948	.949	.950							
86	.949	.950								
88	.950									

REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

Observed temperature in °F	Observed specific gravities									
	0.950	0.951	0.952	0.953	0.954	0.955	0.956	0.957	0.958	0.959
	Corresponding specific gravities at 60°/60° F									
30	0.939	0.940	0.941	0.942	0.943	0.944	0.945	0.916	0.497	0.948
32	.940	.941	.942	.943	.944	.945	.946	.497	.948	.949
34	.940	.941	.942	.943	.944	.945	.946	.947	.948	.949
36	.941	.942	.943	.944	.945	.946	.947	.948	.949	.950
38	.942	.943	.944	.945	.946	.947	.948	.949	.950	
40	.9430	.9440	.9450	.9460	.9470	.9480	.9490	.9500		
42	.9435	.9445	.9455	.9465	9475	.9485	.9495			
44	.9445	.9455	.9465	.9475	.9485	.9495	.9500			
46	.9450	.9460	.9470	.9480	.9490	.9500				
48	.9460	.9470	.9480	.9490	.9500					
50	.9465	.9475	.9485	.9495						
52	.9470	.9480	.9190	.9500						
54	.9480	.9490	.9500							
56	.9485	.9195								
58	.9495	.9500								
60	.9500									

Temperature Corrections of Baume Gravity Readings at Various Temperatures to 60°F.

(MODULUS 140.)

Observed temperature °F	Observed Degrees Baume′							
	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0
	Add to Observed Degrees Baume′							
30	1.7	2.0	2.4	3.0	3.7	4.3	5.0	5.7
32	1.6	1.9	2.3	2.8	3.4	4.0	4.7	5.3
34	1.5	1.8	2.1	2.6	3.1	3.7	4.3	4.9
36	1.4	1.6	2.0	2.4	2.9	3.4	4.0	4.6
38	1.3	1.5	1.8	2.2	2.6	3.1	3.6	4.2
40	1.2	1.4	1.6	2.0	2.4	2.8	3 2	3.8
42	1.1	1.2	1.5	1.8	2.2	2.5	2.9	3.4
44	.9	1.1	1.3	1.6	2.0	2.2	2.6	3.0
46	.8	.9	1.1	1.4	1.7	1.9	2.3	2.7
48	.7	.8	.8	1.2	1.4	1.6	2.0	2.3
50	.6	.7	.8	1.0	1.2	1.4	1.6	1.9
52	.5	.6	.7	.8	1.0	1.1	1.3	1.5
54	.3	.4	.5	.6	.8	.9	1.0	1.1
56	.2	.3	.3	.4	.5	.6	.6	.7
58	.1	.1	.1	.2	.3	.3	.3	.4
	Subtract from Observed Degrees Baume′							
60	.0	.0	.0	.0	.0	.0	.0	.0
62	.1	.1	.1	.2	.2	.3	.3	.4
64	.2	.3	.3	.4	.4	.6	.6	.7
66	.3	.4	.5	.6	.7	.8	.9	1.0
68	.5	.6	.6	.7	.9	1.1	1.3	1.4
70	.6	.7	.8	.9	1.1	1.4	1.6	1.7
72	.7	.8	.9	1.1	1.3	1.6	1.9	2.1
74	.8	.9	1.1	1.3	1.6	1.8	2.2	2.5
76	.9	1.1	1.3	1.5	1.8	2.1	2.5	2.8
78	1.0	1.2	1.4	1.7	2.0	2.4	2.8	3.1
80	1.1	1.3	1.5	1.8	2.2	2.6	3.1	3.5
82	1.2	1.4	1.7	2.0	2.5	2.9	3.4	3.9
84	1.3	1.5	1.8	2.2	2.7	3.2	3.7	4.3
86	1.4	1.7	2.0	2.4	2.9	3.4	4.0	4.6
88	1.6	1.8	2.1	2.6	3.1	3.7	4.2	4.9
90	1.7	2.0	2.3	2.7	3.3	3.9	4.5	5.2
92	1.8	2.1	2.4	2.9	3.5	4.2	4.8	5.6
94	1.9	2.2	2.6	3.1	3 8	4.4	5.1	5.9
96	2.0	2.3	2.7	3.3	4.0	4.6	5.4	6.3
98	2.1	2.4	2.9	3.4	4.2	4.9	5.7	6.6
100	2.2	2.6	3.0	3.6	4.4	5.1	6.0	6.9
102	2.3	2.7	3.2	3.8	4.6	5.4	6.3	7.2
104	2.4	2.9	3.3	4.0	4.8	5.7	6.6	7.5
106	2.5	3.0	3.5	4.2	5.0	5.9	6.9	7.9
108	2.7	3.1	3.6	4.3	5.2	6.2	7.2	8.2
110	2.8	3.2	3.7	4.4	5.4	6.4	7.5	8.5
112	2.9	3.3	3.9	4.6	5.6	6.7	7.7	8.8
114	3.0	3.4	4.0	4.7	5.8	6.9	7.9	9.1
116	3.1	3.6	4.1	4.9	6.0	7.1	8.2	9.4
118	3.2	3.7	4.3	5.1	6.2	7.3	8.5	9.8
120	3.3	3.8	4.4	5.3	6.4	7.5	8.8	10.1

Comparison of Temperatures by the Fahrenheit and Centigrade Scales

Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
—273°	—459.4						
Absolute Zero							
—200°	—328.0	—5.6	+22.0	15.6	60.0	36.1	97.0
Temperature of		—5.0	+23.0	16.0	60.8	36.7	98.0
Liquid Air		—4.4	+24.0	16.1	61.0	37.0	98.6
—130°	—202.0	—4.0	+24.8	16.7	62.0	37.2	99.0
Pure Grain Alcohol		—3.9	+25.0	17.0	62.6	37.8	100.0
Freezes		—3.3	+26.0	17.2	63.0	38.0	100.4
— 70°	— 94.0	—3.0	+26.6	17.8	64.0	38.3	101.0
Ammonia Freezes		—2.8	+27.0	18.0	64.4	38.9	102.0
—(75°C)		—2.2	+28.0	18.3	65.0	39.0	102.2
— 40°	— 40.	—2.0	+28.4	18.9	66.0	39.4	103.0
Mercury Freezes		—1.7	+29.0	19.0	66.2	40.0	104.0
(—39.5C)		—1.1	+30.0	19.4	67.0	40.6	105.0
— 30°	— 22.	—1.0	+30.2	20.0	68.0	41.0	105.8
Ammonia Liquefies at		—0.6	+31.0	20.6	69.0	41.1	106.0
—33.7°C		0.	+32.0	21.0	69.8	41.7	107.0
—28	—18.4	+0.6	+33.0	21.1	70.0	42.0	107.6
—26	—14.8	1.0	33.8	21.7	71.0	42.2	108.0
—24	—11.2	1.1	34.0	22.0	71.6	42.8	109.0
—22	— 7.6	1.7	35.0	22.2	72.0	43.0	109.4
—20	— 4.0	2.0	35.6	22.8	73.0	43 3	110.0
—19	— 2.2	2.2	36.0	23.0	73.4	43.9	111.0
—18	— 0.4	2.8	37.0	23.3	74.0	44.0	111.2
—17.8	— 0.0	3.0	37.4	23.9	75.0	44.4	112.0
—17.2	+ 1.0	3.3	38.0	24.0	75.2	45.0	113.0
—17.0	+ 1.4	3.9	39.0	21.4	76.0	45.6	114.0
—16.7	+ 2.0	4.0	39.2	25.0	77.0	46.0	114.8
—16.1	+ 3.0	4.4	40.0	25.6	78.0	46.1	115.0
—16.0	+ 3.2	5.0	41.0	26.0	78.8	46.7	116.0
—15.6	+ 4.0	5.6	42.0	26.1	79.0	47.0	116.6
—15.0	+ 5.0	6.0	42.8	26.7	80.0	47.2	117.0
—14.4	+ 6.0	6.1	43.0	27.0	80.6	47.8	118.0
—14.0	+ 6.8	6.7	44.0	27.2	81.0	48.0	118.4
—13.9	+ 7.0	7.0	44.6	27.8	82.0	48.3	119.0
—13.3	+ 8.0	7.2	45.0	28.0	82.4	48.9	120.0
—13.0	+ 8.6	7.8	46.0	28.3	83.0	49.0	120.2
—12.8	+ 9.0	8.0	46.4	28.9	84.0	49.4	121.0
—12.2	+10.0	8.3	47.0	29.0	84.2	50.0	122.0
—12.0	+10.4	8.9	48.0	29.4	85.0	50.6	123.0
—11.7	+11.0	9.0	48.2	30.0	86.0	51.0	123.8
—11.1	+12.0	9.4	49.0	30.6	87.0	51.1	124.0
—11.0	+12.2	10.0	50.0	31.0	87.8	51.7	125.0
—10.6	+13.0	10.6	51.0	31.1	88.0	52.0	125.6
—10.0	+14.0	11.0	51.8	31.7	89.0	52.2	126.0
— 9.4	+15.0	11.1	52.0	32.0	89.6	52.8	127.0
— 9.0	+15.8	11.7	53.0	32.2	90.0	53.0	127.4
— 8.9	+16.0	12.0	53.6	32.8	91.0	53.3	128.0
— 8.3	+17.0	12.2	54.0	33.0	91.4	53.9	129.0
— 8.0	+17.6	12.8	55.0	33.3	92.0	54.0	129.2
— 7.8	+18.0	13.0	55.4	33.9	93.0	54.4	130.0
— 7.2	+19.0	13.3	56.0	34.0	93.2	55.0	131.0
— 7.0	+19.4	13.9	57.0	31.4	94.0	55.6	132.0
— 6.7	+20.0	14.0	57.2	35.0	95.0	56.0	132.8
— 6.1	+21.0	14.4	58.0	35.6	96.0	56.1	133.0
— 6.0	+21.2	15.0	59.0	36.0	96.8	56.7	134.0

Temperature Conversion Tables

Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
57.0	134.6	77.8	172.0	98.3	209.0	119.0	246.2
57.2	135.0	78.0	172.4	98.9	210.0	119.4	247.0
57.8	136.0	78.3	173.0	99.0	210.2	120.0	248.0
58.0	136.4	78.9	174.0	99.4	211.0	120.6	249.0
58.3	137.0	79.0	174.2	100.0	212.0	121.0	249.8
58.9	138.0	79.4	175.0	100.6	213.0	121.1	250.0
59.0	138.2	80.0	176.0	101.0	213.8	121.7	251.0
59.4	139.0	80.6	177.0	101.1	214.0	122.0	251.6
60.0	140.0	81.0	177.8	101.7	215.0	122.2	252.0
60.6	141.0	81.1	178.0	102.0	215.6	122.8	253.0
61.0	141.8	81.7	179.0	102.2	216.0	123.0	253.4
61.1	142.0	82.0	179.6	102.8	217.0	123.3	254.0
61.7	143.0	82.2	180.0	103.0	217.4	123.9	255.0
62.0	143.6	82.8	181.0	103.3	218.0	124.0	255.2
62.2	144.0	83.0	181.4	103.9	219.0	124.4	256.0
62.8	145.0	83.3	182.0	104.0	219.2	125.0	257.0
63.0	145.4	83.9	183.0	104.4	220.0	125.6	258.0
63.0	146.0	84.0	183.2	105.0	221.0	126.0	258.8
63.9	147.0	84.4	184.0	105.6	222.0	126.1	259.0
64.0	147.2	85.0	185.0	106.0	222.8	126.7	260.0
64.4	148.0	85.6	186.0	106.1	223.0	127.0	260.6
65.0	149.0	86.0	186.8	106.7	224.0	127.2	261.0
65.6	150.0	86.1	187.0	107.0	224.6	127.8	262.0
66.0	150.8	86.7	188.0	107.2	225.0	128.0	262.4
66.1	151.0	87.0	188.6	107.8	226.0	128.3	263.0
66.7	152.0	87.2	189.0	108.0	226.4	128.9	264.0
67.0	152.6	87.8	190.0	108.3	227.0	129.0	264.2
67.2	153.0	88.0	190.4	108.9	228.0	129.4	265.0
67.8	154.0	88.3	191.0	109.0	228.2	130 0	266.0
68.0	154.4	88.9	192.0	109.4	229.0	130.6	267.0
68.3	155.0	89.0	192.2	110.0	230.0	131.0	267.8
68.9	156.0	89.4	193.0	110.6	231.0	131.1	268.0
69.0	156.2	90.0	194.0	111.0	231.8	131.7	269.0
69.4	157.0	90.6	195.0	111.1	232.0	132.0	269.6
70.0	158.0	91.0	195.8	111.7	233.0	132.2	270.0
70.6	159.0	91.1	196.0	112.0	233.6	132.8	271.0
71.0	159.8	91.7	197.0	112.2	234.0	133 0	271.4
71.1	160.0	92.0	197.6	112.8	235.0	133.3	272.0
71.7	161.0	92.2	198.0	113.0	235.4	133.0	273.0
72.0	161.6	92.8	199.0	113.3	236.0	134.0	273.2
72.2	162.0	93.0	199.4	113.9	237.0	134.4	274.0
72.8	163.0	93.3	200.0	114.0	237.2	135.0	275.0
73.0	163.4	93.9	201.0	114.4	238.0	135.6	276.0
73.3	164.0	94.0	201.2	115.0	239.0	136.0	276.8
73.9	165.0	94.4	202.0	115.6	240.0	136.1	277.0
74.0	165.2	95.0	203.0	116.0	240.8	136.7	278.0
74.4	166.0	95.6	204.0	116.1	241.0	137.0	278.6
75.0	167.0	96.0	204.8	116.7	242.0	137.2	279.0
75.6	168.0	96.1	205.0	117.0	242.6	137.8	280.0
76.0	168.8	96.7	206.0	117.2	243.0	138.0	280.4
76.1	169.0	97.0	206.6	117.8	244.0	138.3	281.0
76.7	170.0	97.2	207.0	118.0	244.4	138.9	282.0
77.0	170.6	97.8	208.0	118.3	245.0	139.0	282.2
77.2	171.6	98.0	208.4	118.9	246.0	139.4	283.0

TEMPERATURE CONVERSION TABLES—Continued.

Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
140.0	284.0	215.0	419.0	590.0	1094.0	1360.0	2480.0
140.6	285.0	220.0	428.0	600.0	1112.0	1380.0	2516.0
141.0	285.8	225.0	437.0	610.0	1130.0	1400.0	2552.0
141.1	286.0	230.0	446.0	620.0	1148.0	1420.0	2588.0
141.7	287.0	235.0	455.0	630.0	1166.0	1440.0	2624.0
142.0	287.6	240.0	464.0	640.0	1184.0	1460.0	2660.0
142.2	288.0	245.0	473.0	650.0	1202.0	1480.0	2696.0
142.8	289.0	250.0	482.0	660.0	1220.0	1500.0	2732.0
143.0	289.4	254.0	489.2	670.0	1238.0	1520.0	2768.0
143.3	290.0	255.0	491.0	680.0	1256.0	1540.0	2804.0
143.9	291.0	260.0	500.0	690.0	1274.0	1560.0	2840.0
144.0	291.2	265.0	509.0	700.0	1292.0	1580.0	2876.0
144.4	292.0	270.0	518.0	710.0	1310.0	1600.0	2912.0
145.0	293.0	275.0	527.0	720.0	1328.0	1620.0	2948.0
145.6	294.0	280.0	536.0	730.0	1346.0	1640.0	2984.0
146.0	294.8	283.0	541.4	740.0	1364.0	1660.0	3020.0
146.1	295.0	285.0	545.0	750.0	1382.0	1680.0	3056.0
146.7	296.0	288.0	550.4	760.0	1400.0	1700.0	3092.0
147.0	296.6	290.0	554.0	770.0	1418.0	1720.0	3128.0
147.2	297.0	295.0	563.0	780.0	1436.0	1740.0	3164.0
147.8	298.0	300.0	572.0	790.0	1454.0	1760.0	3200.0
148.0	298.4	305.0	581.0	800.0	1472.0	1780.0	3236.0
148.3	299.0	310.0	590.0	810.0	1490.0	1800.0	3272.0
148.9	300.0	315.0	599.0	820.0	1508.0	1825.0	3317.0
149.0	300.2 ~~302.0~~	320.0	608.0	830.0	1526.0	1850.0	3362.0
149.4	301.0	325.0	617.0	840.0	1544.0	1875.0	3407.0
150.0	302.0	330.0	626.0	850.0	1562.0	1900.0	3452.0
152.0	305.6	335.0	635.0	860.0	1580.0	1925.0	3497.0
154.0	309.2	340.0	644.0	870.0	1598.0	1950.0	3542.0
156.0	312.8	345.0	653.0	880.0	1616.0	1975.0	3587.0
158.0	316.4	350.0	662.0	890.0	1634.0	2000.0	3632.0
160.0	320.0	360.0	680.0	900.0	1652.0	2400.0	3812.0
162.0	323.6	370.0	698.0	920.0	1688.0	2500.0	4532.0
164.0	327.2	380.0	716.0	940.0	1724.0	3000.0	5432.0
166.0	330.8	390.0	734.0	960.0	1760.0	3500.0	6332.0
168.0	334.4	400.0	752.0	980.0	1796.0	4000.0	7232.0
170.0	338.0	410.0	770.0	1000.0	1832.0	5000.0	9032.0
172.0	341.6	420.0	788.0	1020.0	1868.0	6000.0	10832.0
174.0	345.2	430.0	806.0	1040.0	1904.0		
176.0	348.8	440.0	824.0	1060.0	1940.0		
178.0	352.4	450.0	842.0	1080.0	1976.0		
180.0	356.0	460.0	860.0	1100.0	2012.0		
182.0	359.6	470.0	878.0	1120.0	2048.0		
184.0	363.2	480.0	896.0	1140.0	2084.0		
186.0	366.8	490.0	914.0	1160.0	2120.0		
188.0	370.4	500.0	932.0	1180.0	2156.0		
190.0	374.0	510.0	950.0	1200.0	2192.0		
192.0	377.6	520.0	968.0	1220.0	2228.0		
194.0	381.2	530.0	986.0	1240.0	2264.0		
196.0	384.8	540.0	1004.0	1260.0	2300.0		
198.0	388.4	550.0	1022.0	1280.0	2336.0		
200.0	392.0	560.0	1040.0	1300.0	2372.0		
205.0	401.0	570.0	1058.0	1320.0	2408.0		
210.0	410.0	580.0	1076.0	1340.0	2444.0		

TEMPERATURE READING CONVERSION FACTORS.

Temp. Centigrade $= \frac{5}{9}(F.-32) = \frac{5}{4}$ R.
Temp. Fahrenheit $= \frac{9}{5}$ C. $+ 32 = \frac{9}{4}$ R. $+ 32$.
Temp. Reaumur $= \frac{4}{5}$ C. $= \frac{4}{9}$ (F.—32).

Specific Gravity and Content of Sulphuric Acid

Specific Gravity 15°/4° in vacuo	100 parts by weight correspond to		1 liter contains grams		Specific Gravity 15°/4° in vacuo	100 parts by weight correspond to		1 liter contains grams	
	% SO_3	% H_2SO_4	SO_3	H_2SO_4		% SO_3	% H_2SO_4	SO_3	H_2SO_4
1.000	0.07	0.09	1	1	1.190	21.26	26.04	253	310
1.005	0.68	0.83	7	8	1.195	21.78	26.68	260	319
1.010	1.28	1.57	13	16	1.200	22.30	27.30	268	328
1.015	1.88	2.30	19	23	1.205	22.82	27.95	275	337
1.020	2.47	3.03	25	31	1.210	23.33	28.58	282	346
1.025	3.07	3.76	32	39	1.215	23.84	29.21	290	355
1.030	3.67	4.40	38	46	1.220	24.36	29.84	297	364
1.035	4.27	5.23	44	54	1.225	24.88	30.48	305	373
1.040	4.87	5.96	51	62	1.230	25.39	31.11	312	382
1.045	5.45	6.67	57	71	1.235	25.88	31.70	320	391
1.050	6.02	7.37	63	77	1.240	26.35	32.28	327	400
1.055	6.59	8.07	70	85	1.245	26.83	32.86	334	409
1.060	7.16	8.77	76	93	1.250	27.29	33.43	341	418
1.065	7.73	9.47	82	102	1.255	27.76	34.00	348	426
1.070	8.32	10.19	89	109	1.260	28.22	34.57	356	435
1.075	8.90	10.90	96	117	1.265	28.69	35.14	363	444
1.080	9.47	11.60	103	125	1.270	29.15	35.71	370	454
1.085	10.04	12.30	109	133	1.275	29.62	36.29	377	462
1.090	10.60	12.99	116	142	1.280	30.10	36.87	385	472
1.095	11.16	13.67	122	150	1.285	30.57	37.45	393	481
1.100	11.71	14.35	129	158	1.290	31.04	38.03	400	490
1.105	12.27	15.03	136	166	1.295	31.52	38.61	408	500
1.110	12.82	15.71	143	175	1.300	31.99	39.19	416	510
1.115	13.36	16.36	149	183	1.305	32.46	39.77	424	519
1.120	13.89	17.01	156	191	1.310	32.94	40.35	432	529
1.125	14.42	17.66	162	199	1.315	33.41	40.93	439	538
1.130	14.95	18.31	169	207	1.320	33.88	41.50	447	548
1.135	15.48	18.96	176	215	1.325	34.35	42.08	455	557
1.140	16.01	19.61	183	223	1.330	34.80	42.66	462	567
1.145	16.54	20.26	189	231	1.335	35.27	43.20	471	577
1.150	17.07	20.91	196	239	1.340	35.71	43.74	479	586
1.155	17.59	21.55	203	248	1.345	36.14	44.28	486	596
1.160	18.11	22.19	210	257	1.350	36.58	44.82	494	605
1.165	18.64	22.83	217	266	1.355	37.02	45.35	502	614
1.170	19.16	23.47	224	275	1.360	37.45	45.88	509	624
1.175	19.69	24.12	231	283	1.365	37.89	46.41	517	633
1.180	20.21	24.76	238	292	1.370	38.32	46.94	525	643
1.185	20.73	25.40	246	301	1.375	38.75	47.47	533	653

SPECIFIC GRAVITY AND CONTENT OF SULPHURIC ACID.—Con.

Specific Gravity 15°/4° in vacuo	100 parts by weight correspond to % SO_3	100 parts by weight correspond to % H_2SO_4	1 liter contains grams SO_3	1 liter contains grams H_2SO_4	Specific Gravity 15°/4° in vacuo	100 parts by weight correspond to % SO_3	100 parts by weight correspond to % H_2SO_4	1 liter contains grams SO_3	1 liter contains grams H_2SO_4
1.380	39.18	48.00	541	662	1.590	55.18	67.59	877	1075
1.385	39.62	48.53	549	672	1.595	55.56	68.05	886	1085
1.390	40.05	49.06	557	682	1.600	55.93	68.51	897	1096
1.395	40.48	49.59	564	692	1.605	56.30	68.97	904	1107
1.400	40.91	50.11	573	702	1.610	56.68	69.43	913	1118
1.405	41.33	50.63	581	711	1.615	57.05	69.89	921	1128
1.410	41.76	51.15	589	721	1.620	57.40	70.32	930	1139
1.415	42.17	51.66	597	730	1.625	57.75	70.74	938	1150
1.420	42.57	52.15	604	740	1.630	58.09	71.16	947	1160
1.425	42.96	52.63	612	750	1.635	58.43	71.57	955	1170
1.430	43.36	53.11	620	759	1.640	58.77	71.99	964	1181
1.435	43.75	53.59	628	769	1.645	59.10	72.40	972	1192
1.440	44.14	54.07	636	779	1.650	59.45	72.82	981	1202
1.445	44.53	54.55	643	789	1.655	59.78	73.23	989	1212
1.450	44.92	55.03	651	798	1.660	60.11	73.64	998	1222
1.455	45.31	55.50	659	808	1.665	60.46	74.07	1007	1233
1.460	45.69	55.97	667	817	1.670	60.82	74.51	1016	1244
1.465	46.07	56.43	675	827	1.675	61.20	74.97	1025	1256
1.470	46.45	56.90	683	837	1.680	61.57	75.42	1034	1267
1.475	46.83	57.37	691	846	1.685	61.93	75.86	1043	1278
1.480	47.21	57.83	699	856	1.690	62.29	76.30	1053	1289
1.485	47.57	58.28	707	865	1.695	62.64	76.73	1062	1301
1.490	47.95	58.74	715	876	1.700	63.00	77.17	1071	1312
1.495	48.34	59.22	723	885	1.705	63.35	77.60	1080	1323
1.500	48.73	59.70	731	896	1.710	63.70	78.04	1089	1334
1.505	49.12	60.18	739	906	1.715	64.07	78.48	1099	1346
1.510	49.51	60.65	748	916	1.720	64.43	78.92	1108	1357
1.515	49.89	61.12	756	926	1.725	64.78	79.36	1118	1369
1.520	50.28	61.59	764	936	1.730	65.14	79.80	1127	1381
1.525	50.66	62.06	773	946	1.735	65.50	80.24	1136	1392
1.530	51.04	62.53	781	957	1.740	65.86	80.68	1146	1404
1.535	51.43	63.00	789	967	1.745	66.22	81.12	1156	1416
1.540	51.78	63.43	797	977	1.750	66.58	81.56	1165	1427
1.545	52.12	63.85	805	987	1.755	66.94	82.00	1175	1439
1.550	52.46	64.26	813	996	1.760	67.30	82.44	1185	1451
1.555	52.79	64.67	821	1006	1.765	67.65	82.88	1194	1463
1.560	53.12	65.08	829	1015	1.770	68.02	83.32	1204	1475
1.565	53.46	65.49	837	1025	1.775	68.49	83.90	1216	1489
1.570	53.80	65.90	845	1035	1.780	68.98	84.50	1228	1504
1.575	54.13	66.30	853	1044	1.785	69.47	85.10	1240	1519
1.580	54.46	66.71	861	1054	1.790	69.96	85.70	1252	1534
1.585	54.80	67.13	869	1064	1.795	70.46	86.30	1265	1549

SPECIFIC GRAVITY AND CONTENT OF SULPHURIC ACID.—Con.

Specific Gravity $\frac{15°}{4°}$ in vacuo	100 parts by weight correspond to		1 liter contains grams		Specific Gravity $\frac{15°}{4°}$ in vacuo	100 parts by weight correspond to		1 liter contains grams	
	% SO_2	% H_3SO_4	SO_3	H_2SO_4		% SO_2	% H_3SO_4	SO_3	H_2SO_4
1.800	70.94	86.90	1277	1564	1.833	75.72	92.75	1388	1700
1.805	71.50	87.60	1291	1581	1.834	75.96	93.05	1393	1706
1.810	72.08	88.30	1305	1598	1.835	76.27	93.43	1400	1713
1.815	72.69	89.05	1319	1621	1.836	76.57	93.80	1405	1722
1.820	73.51	90.05	1338	1639	1.837	76.90	94.20	1412	1730
1.821	73.63	90.20	1341	1643	1.838	77.23	94.60	1419	1739
1.822	73.80	90.40	1345	1647	1.839	77.55	95.00	1426	1748
1.823	73.96	90.60	1318	1651	1.840	78.04	95.60	1436	1759
1.824	74.12	90.80	1352	1656	1.8405	78.33	95.95	1441	1765
1.825	74.29	91.00	1356	1661	1.8410	79.19	97.00	1458	1786
1.826	74.49	91.25	1360	1666	1.8415	79.76	97.70	1469	1799
1.827	74.69	91.50	1364	1671	1.8410	80.16	98.20	1476	1808
1.828	74.86	91.70	1368	1676	1.8405	80.57	98.70	1483	1816
1.829	75.08	91.90	1372	1681	1.8400	80.98	99.20	1490	1825
1.830	75.19	92.10	1376	1685	1.8395	81.18	99.45	1494	1830
1.831	75.35	92.30	1380	1690	1.8390	81.39	99.70	1497	1834
1.832	75.53	92.52	1384	1695	1.8385	81.59	99.95	1500	1838

Percentage of Sulphur Trioxide and Sulphuric Acid in Fuming Sulphuric Acid

Total SO_3 as found by titration.	The acid contains %		Total SO_3 as found by titration.	The acid contains %		Total SO_3 as found by titration.	The acid Contains	
	H_2SO_4	SO_3		H_2SO_4	SO_3		H_2SO_4	SO_3
81.8326	100	0	87.8775	66	34	93.9389	33	67
81.8163	99	1	88.0612	65	35	94.1224	32	68
82.0000	98	2	88.2448	64	36	94.3061	31	69
82.1836	97	3	88.4285	63	37	94.4897	30	70
82.3674	96	4	88.6122	62	38	94.6734	29	71
82.5510	95	5	88.7959	61	39	94.8571	28	72
82.7346	94	6	88.9795	60	40	95.0408	27	73
82.9183	93	7	89.1632	59	41	95.2244	26	74
83.1020	92	8	89.3469	58	42	95.4081	25	75
83.2857	91	9	89.5306	57	43	95.5918	24	76
83.4693	90	10	89.7142	56	44	95.7755	23	77
83.6530	89	11	89.8979	55	45	95.9591	22	78
83.8367	88	12	90.0816	54	46	96.1428	21	79
84.0204	87	13	90.2653	53	47	96.3265	20	80
84.2040	86	14	90.4489	52	48	96.5102	19	81
84.3877	85	15	90.6326	51	49	96.6938	18	82
84.5714	84	16	90.8163	50	50	96.8775	17	83
84.7551	83	17	91.0000	49	51	97.0612	16	84
84.9387	82	18	91.1836	48	52	97.2448	15	85
85.1224	81	19	91.3673	47	53	97.4285	14	86
85.3061	80	20	91.5510	46	54	97.6122	13	87
85.4897	79	21	91.7346	45	55	97.7959	12	88
85.6734	78	22	91.9183	44	56	97.9795	11	89
85.8571	77	23	92.1020	43	57	98.1632	10	90
86.0408	76	24	92.2857	42	58	98.3469	9	91
86.2244	75	25	92.4693	41	59	98.5306	8	92
86.4081	74	26	92.6530	40	60	98.7142	7	93
86.5918	73	27	92.8367	39	61	98.8979	6	94
86.7755	72	28	93.0204	38	62	99.0816	5	95
86.9591	71	29	93.2040	37	63	99.2753	4	96
87.1428	70	30	93.3877	36	64	99.4489	3	97
87.3265	69	31	93.5714	35	65	99.6326	2	98
87.5102	68	32	93.7551	34	66	99.8163	1	99
87.6938	67	33						

Specific Gravity Tables

Equivalent of Degrees Baume′ (American Standard) and Specific Gravity at 60° F.

$$\text{Degrees Baume}'=145-\frac{145}{\text{Sp. Gr.}}$$ For Liquids Heavier than Water.

Degrees Baume′	Specific Gravity	Degrees Baume′	Specific Gravity	Degrees Baume′	Specific Gravity	Degrees Baume′	Specific Gravity
0.0	1.0000	.7	1.0262	.4	1.0538	.1	1.0829
.1	1.0007	.8	1.0269	.5	1.0545	.2	1.0837
.2	1.0014	.9	1.0276	.6	1.0553	.3	1.0845
.3	1.0021	4.0	1.0284	.7	1.0561	.4	1.0853
.4	1.0028	.1	1.0291	.8	1.0569	.5	1.0861
.5	1.0035	.2	1.0298	.9	1.0576	.6	1.0870
.6	1.0042	.3	1.0306	8.0	1.0584	.7	1.0878
.7	1.0049	.4	1.0313	.1	1.0592	.8	1.0886
.8	1.0055	.5	1.0320	.2	1.0599	.9	1.0894
.9	1.0062	.6	1.0328	.3	1.0607	12.0	1.0902
1.0	1.0069	.7	1.0335	.4	1.0615	.1	1.0910
.1	1.0076	.8	1.0342	.5	1.0623	.2	1.0919
.2	1.0083	.9	1.0350	.6	1.0630	.3	1.0927
.3	1.0090	5.0	1.0357	.7	1.0638	.4	1.0935
.4	1.0097	.1	1.0365	.8	1.0646	.5	1.0943
.5	1.0105	.2	1.0372	.9	1.0654	.6	1.0952
.6	1.0112	.3	1.0379	9.0	1.0662	.7	1.0960
.7	1.0119	.4	1.0387	.1	1.0670	.8	1.0968
8	1.0126	.5	1.0394	.2	1.0677	.9	1.0977
.9	1.0133	.6	1.0402	.3	1.0685	13.0	1.0985
2.0	1.0140	.7	1.0409	.4	1.0693	.1	1.0993
.1	1.0147	.8	1.0417	.5	1.0701	.2	1.1002
.2	1.0154	.9	1.0424	.6	1.0709	.3	1.1010
.3	1.0161	6.0	1.0432	.7	1.0717	.4	1.1018
.4	1.0168	.1	1.0439	.8	1.0725	.5	1.1027
.5	1.0175	.2	1.0447	.9	1.0733	.6	1.1035
.6	1.0183	.3	1.0454	10.0	1.0741	.7	1.1043
.7	1.0190	.4	1.0462	.1	1.0749	.8	1.1052
.8	1.0197	.5	1.0469	.2	1.0757	.9	1.1060
.9	1.0204	.6	1.0477	.3	1.0765	14.0	1.1069
3.0	1.0211	.7	1.0484	.4	1.0773	.1	1.1077
.1	1.0218	.8	1.0492	5	1.0781	.2	1.1086
.2	1.0226	.9	1.0500	.6	1.0789	.3	1.1094
.3	1.0233	7.0	1.0507	.7	1.0797	.4	1.1103
.4	1.0240	.1	1.0515	.8	1.0805	.5	1.1111
.5	1.0247	.2	1.0522	.9	1.0813	.6	1.1120
.6	1.0255	.3	1.0530	11.0	1.0821	.7	1.1128

EQUIVALENT BAUME′ DEGREES.—Con.

Degrees Baume′	Specific Gravity	Degrees Baume′	Specific Gravity	Degrees Baume′	Specific Gravity	Degrees Baume′	Specific Gravity
.8	1.1137	.2	1.1526	.6	1.1944	28.0	1.2393
.9	1.1145	.3	1.1535	.7	1.1954	.1	1.2404
15.0	1.1154	.4	1.1545	.8	1.1964	.2	1.2414
.1	1.1162	.5	1.1554	.9	1.1974	.3	1.2425
.2	1.1171	.6	1.1563	24.0	1.1983	.4	1.2436
.3	1.1180	.7	1.1572	.1	1.1993	.5	1.2446
.4	1.1188	.8	1.1581	.2	1.2003	.6	1.2457
.5	1.1197	.9	1.1591	.3	1.2013	.7	1.2468
.6	1.1206	20.0	1.1600	.4	1.2023	.8	1.2478
.7	1.1214	.1	1.1609	.5	1.2033	.9	1.2489
.8	1.1223	.2	1.1619	.6	1.2043	29.0	1.2500
.9	1.1232	.3	1.1628	.7	1.2053	.1	1.2511
16.0	1.1240	.4	1.1637	.8	1.2063	.2	1.2522
.1	1.1249	.5	1.1647	.9	1.2073	.3	1.2532
.2	1.1258	.6	1.1656	25.0	1.2083	.4	1.2543
.3	1.1267	.7	1.1665	.1	1.2093	.5	1.2554
.4	1.1275	.8	1.1675	.2	1.2104	.6	1.2565
.5	1.1284	.9	1.1684	.3	1.2114	.7	1.2576
.6	1.1293	21.0	1.1694	.4	1.2124	.8	1.2587
.7	1.1302	.1	1.1703	.5	1.2134	.9	1.2598
.8	1.1310	.2	1.1712	.6	1.2144	30.0	1.2609
.9	1.1319	.3	1.1722	.7	1.2154	.1	1.2620
17.0	1.1328	.4	1.1731	.8	1.2164	.2	1.2631
.1	1.1337	.5	1.1741	.9	1.2175	.3	1.2642
.2	1.1346	.6	1.1750	26.0	1.2185	.4	1.2653
.3	1.1355	.7	1.1760	.1	1.2195	.5	1.2664
.4	1.1364	.8	1.1769	.2	1.2205	.6	1.2675
.5	1.1373	.9	1.1779	.3	1.2216	.7	1.2686
.6	1.1381	22.0	1.1789	.4	1.2226	.8	1.2697
.7	1.1390	.1	1.1798	.5	1.2236	.9	1.2708
.8	1.1399	.2	1.1808	.6	1.2247	31.0	1.2719
.9	1.1408	.3	1.1817	.7	1.2257	.1	1.2730
18.0	1.1417	.4	1.1827	.8	1.2267	.2	1.2742
.1	1.1426	.5	1.1837	.9	1.2278	.3	1.2753
.2	1.1435	.6	1.1846	27.0	1.2288	.4	1.2764
.3	1.1444	.7	1.1856	.1	1.2299	.5	1.2775
.4	1.1453	.8	1.1866	.2	1.2309	.6	1.2787
.5	1.1462	.9	1.1876	.3	1.2319	.7	1.2798
.6	1.1472	23.0	1.1885	.4	1.2330	.8	1.2809
.7	1.1481	.1	1.1895	.5	1.2340	.9	1.2821
.8	1.1490	.2	1.1905	.6	1.2351	32.0	1.2832
.9	1.1499	.3	1.1915	.7	1.2361	.1	1.2843
19.0	1.1508	.4	1.1924	.8	1.2372	.2	1.2855
.1	1.1517	.5	1.1934	.9	1.2383	.3	1.2866

EQUIVALENT BAUME′ DEGREES—Con.

Degrees Baume′	Specific Gravity	Degrees Baume′	Specific Gravity	Degrees Baume′	Specific Gravity	Degrees Baume′	Specific Gravity
.4	1.2877	.8	1.3401	.2	1.3969	.6	1.4588
.5	1.2889	.9	1.3414	.3	1.3983	.7	1.4602
.6	1.2900	37.0	1.3426	.4	1.3996	.8	1.4617
.7	1.2912	.1	1.3438	.5	1.4010	.9	1.4632
.8	1.2923	.2	1.3451	.6	1.4023	46.0	1.4646
.9	1.2935	.3	1.3463	.7	1.4037	.1	1.4661
33.0	1.2946	.4	1.3476	.8	1.4050	.2	1.4676
.1	1.2958	.5	1.3488	.9	1.4064	.3	1.4691
.2	1.2970	.6	1.3501	42.0	1.4078	.4	1.4706
.3	1.2981	.7	1.3514	.1	1.4091	.5	1.4721
.4	1.2993	.8	1.3526	.2	1.4105	.6	1.4736
.5	1.3004	.9	1.3539	.3	1.4119	.7	1.4751
.6	1.3016	38.0	1.3551	.4	1.4133	.8	1.4766
.7	1.3028	.1	1.3564	.5	1.4146	.9	1.4781
.8	1.3040	.2	1.3577	.6	1.4160	47.0	1.4796
.9	1.3051	.3	1.3590	.7	1.4174	.1	1.4811
34.0	1.3063	.4	1.3602	.8	1.4188	.2	1.4826
.1	1.3075	.5	1.3615	.9	1.4202	.3	1.4841
.2	1.3087	.6	1.3628	43.0	1.4216	.4	1.4857
.3	1.3098	.7	1.3641	.1	1.4230	.5	1.4872
.4	1.3110	.8	1.3653	.2	1.4244	.6	1.4887
.5	1.3122	.9	1.3666	.3	1.4258	.7	1.4902
.6	1.3134	39.0	1.3679	.4	1.4272	.8	1.4918
.7	1.3146	.1	1.3692	.5	1.4286	.9	1.4933
.8	1.3158	.2	1.3705	.6	1.4300	48.0	1.4948
.9	1.3170	.3	1.3718	.7	1.4314	.1	1.4964
35.0	1.3182	.4	1.3731	.8	1.4328	.2	1.4979
.1	1.3194	.5	1.3744	.9	1.4342	.3	1.4995
.2	1.3206	.6	1.3757	44.0	1.4356	.4	1.5010
.3	1.3218	.7	1.3770	.1	1.4371	.5	1.5026
.4	1.3230	.8	1.3783	.2	1.4385	.6	1.5041
.5	1.3242	.9	1.3796	.3	1.4399	.7	1.5057
.6	1.3254	40.0	1.3810	.4	1.4414	.8	1.5073
.7	1.3266	.1	1.3823	.5	1.4428	.9	1.5088
.8	1.3278	.2	1.3836	.6	1.4442	49.0	1.5104
.9	1.3291	.3	1.3849	.7	1.4457	.1	1.5120
36.0	1.3303	.4	1.3862	.8	1.4471	.2	1.5136
.1	1.3315	.5	1.3876	.9	1.4486	.3	1.5152
.2	1.3327	.6	1.3889	45.0	1.4500	.4	1.5167
.3	1.3329	.7	1.3902	.1	1.4515	.5	1.5183
.4	1.3352	.8	1.3916	.2	1.4529	.6	1.5199
.5	1.3364	.9	1.3929	.3	1.4544	.7	1.5215
.6	1.3376	41.0	1.3942	.4	1.4558	.8	1.5231
.7	1.3389	.1	1.3956	.5	1.4573	.9	1.5247

EQUIVALENT BAUME' DEGREES—Con.

Degrees Baume'	Specific Gravity	Degrees Baume'	Specific Gravity	Degrees Baume'	Specific Gravity	Degrees Baume'	Specific Gravity
50.0	1.5263	.4	1.6004	.8	1.6821	.2	1.7726
.1	1.5279	.5	1.6022	.9	1.6841	.3	1.7748
.2	1.5295	.6	1.6040	59.0	1.6860	.4	1.7770
.3	1.5312	.7	1.6058	.1	1.6880	.5	1.7791
.4	1.5328	.8	1.6075	.2	1.6900	.6	1.7813
.5	1.5344	.9	1.6093	.3	1.6919	.7	1.7835
6	1.5360	55.0	1.6111	.4	1.6939	.8	1.7857
.7	1.5376	.1	1.6129	.5	1.6959	.9	1.7879
.8	1.5393	.2	1.6147	.6	1.6979	64.0	1.7901
.9	1.5409	.3	1.6165	.7	1.6999	.1	1.7923
51.0	1.5426	.4	1.6183	.8	1.7019	.2	1.7946
.1	1.5442	.5	1.6201	.9	1.7039	.3	1.7968
.2	1.5458	.6	1.6219	60.0	1.7059	.4	1.7990
.3	1.5475	.7	1.6237	.1	1.7079	.5	1.8012
.4	1.5491	.8	1.6256	.2	1.7099	.6	1.8035
.5	1.5508	.9	1.6274	.3	1.7119	.7	1.8057
.6	1.5525	56.0	1.6292	.4	1.7139	.8	1.8080
.7	1.5541	.1	1.6310	.5	1.7160	.9	1.8102
.8	1.5558	.2	1.6329	.6	1.7180	65.0	1.8125
.9	1.5575	.3	1.6347	7	1.7200	.1	1.8148
52.0	1.5591	.4	1.6366	.8	1.7221	.2	1.8170
.1	1.5608	.5	1.6384	.9	1.7241	.3	1.8193
.2	1.5625	.6	1.6403	61.0	1.7262	.4	1.8216
.3	1.5642	.7	1.6421	.1	1.7282	.5	1.8239
.4	1.5659	.8	1.6440	.2	1.7303	.6	1.8262
.5	1.5676	.9	1.6459	.3	1.7324	.7	1.8285
.6	1.5693	57.0	1.6477	.4	1.7344	.8	1.8308
.7	1.5710	.1	1.6496	.5	1.7365	.9	1.8331
.8	1.5727	.2	1.6515	.6	1.7386	66.0	1.8354
.9	1.5744	.3	1.6534	.7	1.7407	.1	1.8378
53.0	1.5761	.4	1.6553	.8	1.7428	.2	1.8401
.1	1.5778	.5	1.6571	.9	1.7449	.3	1.8424
.2	1.5795	.6	1.6590	62.0	1.7470	.4	1.8448
.3	1.5812	.7	1.6609	.1	1.7491	.4	1.8448
.4	1.5830	.8	1.6628	.2	1.7512	.5	1.8471
.5	1.5847	.9	1.6648	.3	1.7533	.6	1.8495
.6	1.5864	58.0	1.6667	.4	1.7554	.7	1.8519
.7	1.5882	.1	1.6686	.5	1.7576	.8	1.8542
.8	1.5899	.2	1.6705	.6	1.7597	.9	1.8566
.9	1.5917	.3	1.6724	.7	1.7618	67.0	1.8590
54.0	1.5934	.4	1.6744	.8	1.7640	.1	1.8614
.1	1.5952	.5	1.6763	.9	1.7661	.2	1.8638
.2	1.5969	.6	1.6782	63.0	1.7683	.3	1.8662
.3	1.5987	.7	1.6802	.1	1.7705	.4	1.8686

EQUIVALENT BAUME' DEGREES—Con.

Degrees Baume'	Specific Gravity	Degrees Baume'	Specific Gravity	Degrees Baume'	Specific Gravity	Degrees Baume'	Specific Gravity
.5	1.8710	.2	1.8880	.9	1.9054	.6	1.9231
.6	1.8734	.3	1.8905	69.0	1.9079	.7	1.9256
.7	1.8758	.4	1.8930	.1	1.9104	.8	1.9282
.8	1.8782	.5	1.8954	.2	1.9129	.9	1.9308
.9	1.8807	.6	1.8979	.3	1.9155	70.0	1.9333
68.0	1.8831	.7	1.9004	.4	1.9180		
.1	1.8856	.8	1.9029	.5	1.9205		

Sodium Hydroxide Solution at 15° C. (Caustic Soda)

LUNGE.

Specific Gravity	Degrees Baume	Degrees Twaddell	Per Cent Na_2O.	Per Cent NaOH.	1 Liter Contains Grams	
					Na_2O.	NaOH.
1.007	1.0	1.4	0.47	0.61	4	6
1.014	2.8	1.4	0.93	1.20	9	12
1.022	3.1	4.4	1.55	2.00	16	21
1.029	4.1	5.8	2.10	2.70	22	28
1.036	5.1	7.2	2.60	3.35	27	35
1.045	6.2	9.0	3.10	4.00	32	42
1.052	7.2	10.4	3.60	4.64	38	49
1.060	8.2	12.0	4.10	5.29	43	56
1.067	9.1	13.4	4.55	5.87	49	63
1.075	10.1	15.0	5.08	6.55	55	70
10.83	11.1	16.6	5.67	7.31	61	79
1.091	12.1	18.2	6.20	8.00	68	87
1.100	13.2	20.0	6.73	8.68	74	95
1.108	14.1	21.6	7.30	9.42	81	104
1.116	15.1	23.2	7.80	10.06	87	112
1.125	16.1	25.0	8.50	10.97	96	123
1.134	17.1	26.8	9.18	11.84	104	134
1.142	18.0	28.4	9.80	12.64	112	144
1.152	19.1	30.4	10.50	13.55	121	156
1.162	20.2	32.4	11.14	14.37	129	167
1.171	21.2	34.2	11.73	15.13	137	177
1.180	22.1	36.0	12.33	15.91	146	188
1.190	23.1	38.0	13.00	16.77	155	200
1.200	24.2	40.0	13.70	17.67	164	212
1.210	25.2	42.0	14.40	18.58	174	225
1.220	26.1	44.0	15.18	19.58	185	239
1.231	27.2	46.2	15.96	20.59	196	253
1.241	28.2	48.2	16.76	21.42	208	266
1.252	29.2	50.4	17.55	22.64	220	283
1.263	30.2	52.6	18.35	23.67	232	299
1.274	31.2	54.8	19.23	24.81	245	316
1.285	32.2	57.0	20.00	25.80	257	332
1.297	33.2	59.4	20.80	26.83	270	348
1.308	34.1	61.6	21.55	27.80	282	364
1.320	35.2	64.0	22.35	28.83	295	381
1.332	36.1	66.4	23.20	29.93	309	399
1.345	37.2	69.0	24.20	31.22	326	420
1.357	38.1	71.4	25.17	32.47	342	441
1.370	39.2	74.0	26.12	33.69	359	462
1.383	40.2	76.6	27.10	34.96	375	483
1.397	41.2	79.4	28.10	36.25	392	506
1.410	42.2	82.0	29.05	37.47	410	528
1.424	43.2	84.8	30.08	38.80	428	553
1.438	44.2	87.6	31.00	39.99	446	575
1.453	45.2	90.6	32.10	41.41	466	602
1.468	46.2	93.6	33.20	42.83	487	629
1.483	47.2	96.6	34.40	44.38	510	658
1.498	48.2	99.6	35.70	46.15	535	691
1.514	49.2	102.8	36.90	47.60	559	721
1.530	50.2	106.0	38.00	49.02	581	750

The Metric System, Fundamental Equivalents

The fundamental unit of the metric system is the Meter—the unit of length. From this the units of capacity (Liter) and of weight (Gram) were derived. All other units are the decimal subdivisions or multiples of these. These three units are simply related, e. g., for all practical purposes one Cubic Decimeter equals one Liter and one Liter of water weighs one Kilogram. The metric tables are formed by combining the words "Meter," "Gram," and "Liter" with the six numerical prefixes, as in the following tables:

Prefixes.	Meaning.			Units.
milli-	= one thousandth	..1/1000	0.001	
centi-	= one hundredth	...1/100	0.01	"meter" for length
deci-	= one tenth	........1/10	0.1	
Unit	= one	....	1.	"gram" for weight or mass
deka-	= ten	.............10/1	10.	
hecto-	= one hundred	.....100/1	100.	"liter" for capacity
kilo-	= one thousand	....1000/1	1000.	

All lengths, areas, and cubic measures in the following tables are derived from the international meter, the legal equivalent being 1 Meter = 39.37 Inches (law of July 28, 1866). In 1893 the United States Office of Standard Weights and Measures was authorized to derive the yard from the meter, using for the purpose the relation legalized in 1866, 1 Yard = 3600/3937 Meter.

The customary weights derived from the international kilogram are based on the value 1 avoirdupois pound = 453.5924277 grams. This value is carried out farther than that given in the law, but is in accord with the latter as far as it is there given. The value of the troy pound is based upon the relation just mentioned and also the equivalent 5760/7000 avoirdupois pounds equals 1 troy pound.

In the following tables the metric unit has been selected as the common unit so that conversions may be made through the metric unit.

LINEAR DIMENSIONS—CONVERSION FACTORS.

Cm. to A.	A.	A. to Cm.
$1.0000 \cdot 10^{-5}$	KILOMETER = 0.62137 — U. S. miles = 3280.83 ft.	$1.0000 \cdot 10^{5}$
$1.0000 \cdot 10^{-2}$ (a)	METER = 3.28083 ft. = 39.37 inches (legal)	$1.0000 \cdot 10^{2}$
1.0000	CENTIMETER = 0.3937 inch = 10 millimeters	1.0000
$1.0000 \cdot 10$	MILLIMETER = 0.03937 inch = 1000 microns	$1.0000 \cdot 10^{-1}$
$1.0000 \cdot 10^{4}$	MICRON = 0.00003937 inch = 1000 millimicrons	$1.0000 \cdot 10^{-4}$
$1.0000 \cdot 10^{7}$	MILLIMICRON or MICROMILLIMETER = 10 A.U.	$1.0000 \cdot 10^{-7}$
$1.0000 \cdot 10^{8}$	ANGSTROM UNIT = 3.932×10^{-9} inch	$1.0000 \cdot 10^{-8}$
$6.2137 \cdot 10^{-6}$	MILE (Statute) = 5280 feet = 1.609347 kilom.	$1.6093 \cdot 10^{5}$
$1.9883 \cdot 10^{-3}$	ROD or PERCH = 16.5 feet	$5.029 \cdot 10^{2}$
$1.0936 \cdot 10^{-2}$	YARD = 3 feet	$9.144 \cdot 10$
$3.28083 \cdot 10^{-2}$	FOOT = 12 inches	$3.0480 \cdot 10$
$3.937 \cdot 10^{-1}$	INCH = 0.083333 ft.	2.5400
$3.937 \cdot 10^{2}$	MIL = 1/1000 inch	$2.5400 \cdot 10^{-3}$
$8.983 \cdot 10^{-8}$	1° LONGITUDE AT EQUATOR = 69.1713 Statute Miles	$1.1132 \cdot 10^{7}$
$2.0712 \cdot 10^{-6}$	LEAGUE = 3 Statute Miles	$4.8280 \cdot 10^{5}$
$5.3959 \cdot 10^{-6}$	KNOT, NAUTICAL MILE, SEA MILE = 6080.2 (Geographical Mile)	$1.85325 \cdot 10^{5}$
$5.3957 \cdot 10^{-6}$	BRITISH NAUTICAL MILE = 6080.4006466 + feet	$1.85319 \cdot 10^{5}$
$4.97 \cdot 10^{-5}$	FURLONG = 660 feet = 10 chains	$2.01168 \cdot 10^{4}$
$2.7340 \cdot 10^{-4}$	1 CABLE LENGTH = 120 feet	$3.6576 \cdot 10^{3}$
$5.468 \cdot 10^{-3}$	U. S. FATHOM = 6 feet	$1.8288 \cdot 10^{2}$
$4.9709 \cdot 10^{-4}$	CHAIN = 66 feet = 100 links	$2.01168 \cdot 10^{3}$
$4.97 \cdot 10^{-2}$	LINK = 7.92 inches	$2.01168 \cdot 10$
$1.118 \cdot 10^{-2}$	VARA = 33⅓ inches	$8.4760 \cdot 10$
$2.734 \cdot 10^{-4}$	BOLT = 40 yards	$3.7576 \cdot 10^{3}$
$1.1811 \cdot 10^{-1}$	BARLEY CORN = ⅓ inch	8.4667
$4.3744 \cdot 10^{-2}$	SPAN = 9 inches	$2.2860 \cdot 10$
$9.8425 \cdot 10^{-2}$	HAND = 4 inches	$1.0160 \cdot 10$
$1.312 \cdot 10^{-1}$	PALM = 3 inches	7.6200
4.7244	LINE = 1/12 inch	$2.1167 \cdot 10^{-1}$
$2.834 \cdot 10$	POINT = 1/72 inch	$3.5278 \cdot 10^{-2}$

(a) Note $10^{-5} = 1/10^{5} = 1/100000 = 0.00001$.

SQUARE MEASURE, SURFACES, AREAS.

Sq. cm. to A.	A.	A. to sq. cm.
$1.000 \cdot 10^{-8}$	HECTARE = 2.471043930 acres	$1.000 \cdot 10^{8}$
$1.000 \cdot 10^{-6}$(a)	ARE or AR = 119.59852621 sq. yd.	$1.000 \cdot 10^{6}$
$1.000 \cdot 10^{-10}$	SQUARE KILOMETER = 0.386100614 sq. miles	$1.000 \cdot 10^{10}$
$1.000 \cdot 10^{-4}$	SQUARE METER = 10.76386735908 sq. ft.	$1.000 \cdot 10^{4}$
1.000	SQUARE CENTIMETER = 0.15499968997 sq. in.	1.000
$1.000 \cdot 10^{2}$	SQUARE MILLIMETER = 0.001550 sq. in.	$1.000 \cdot 10^{-2}$
$1.0725017 \cdot 10^{-12}$	1 TOWNSHIP = 36 square miles	$9.3239945 \cdot 10^{11}$
$3.86100614 \cdot 10^{-11}$	SQUARE MILE = 640 acres = 2.78784×10^{7} sq. in.	$2.58999847 \cdot 10^{10}$
$2.47104393 \cdot 10^{-8}$	ACRE = 10 sq. chains = 43560 sq. ft. = 0.0015625 sq. mi.	$4.0468726 \cdot 10^{7}$
$3.953670288 \cdot 10^{-6}$	SQ. ROD or POLE = 272.25 sq. ft. = 0.00625 A.	$2.52929537 \cdot 10^{5}$
$1.19598526 \cdot 10^{-4}$	SQUARE YARD = 9 sq. ft. = 1296 sq. in.	$8.3613 \cdot 10^{3}$
$1.0763867359 \cdot 10^{-3}$	SQUARE FOOT = 144 sq. in. = 3.58701×10^{-8} sq. mi.	$9.29034 \cdot 10^{2}$
$1.5499968 \cdot 10^{-1}$	SQUARE INCH = 0.0069444 sq. ft. = 2.491×10^{-10} sq. mi.	6.4516
$1.5499968 \cdot 10^{5}$	SQUARE MIL = 0.000001 sq. in.	$6.4516 \cdot 10^{-6}$
$1.2705 \cdot 10^{5}$	CIRCULAR MIL = (wire) = 0.00000122 sq. in.	$7.871 \cdot 10^{-6}$
$2.47104393 \cdot 10^{-7}$	SQUARE CHAIN = 4356 sq. ft. = 0.1 acre	$4.0468726 \cdot 10^{6}$
$2.47104393 \cdot 10^{-4}$	SQUARE LINK = 62.7264 sq. in. = 0.4356 sq. ft.	$4.0468726 \cdot 10^{3}$
$1.0764 \cdot 10^{-5}$	1 SQUARE (roofs and floors) = 100 sq. ft.	$9.29034 \cdot 10^{4}$

(a) $10^{-8} = 1/10^{8} = 1/100000000 = 0.00000001$

VOLUME, CAPACITY, CUBIC CONTENTS, SPACE.

Cubic centimeter to A.	A.	A. to cubic centimeter.
1.000	CUBIC CENTIMETER = 16.23 minims = 0.0610 cu. in.	1.0000
$1.000 \cdot 10^{-3}$	LITER = 1.056681868 U. S. Qt. = 61.023 cu. in.	$1.000 \cdot 10^{3}$
$1.000 \cdot 10^{-6}$	CUBIC METER = 264.4 U. S. Gal. = 35.3165 cu. ft. (Kiloliter) (stere) = 1.307942772 cu. yd.	$1.000 \cdot 10^{6}$
$6.1023377953 \cdot 10^{-2}$	CUBIC INCH = 0.553 fld. oz. = 0.00058 cu. ft.	$1.6387 \cdot 10$
$3.532 \cdot 10^{-5}$	CUBIC FOOT = 7.48 U. S. Gal. = 1728 cu. in.	$2.8317 \cdot 10^{4}$
$1.308 \cdot 10^{-9}$	CUBIC YARD = 20.197 U. S. Gal. = 27 cu. ft.	$7.64559 \cdot 10^{5}$

U. S. LIQUID AND APOTHECARY MEASURE.

$1.623 \cdot 10$	MINIM = about 1 drop = 0.00376 cu. in.	$6.16119 \cdot 10^{-2}$
$2.705 \cdot 10^{-1}$	FLUID DRAM = 60 minims = 0.2256 cu. in.	3.6967
$8.116 \cdot 10^{-1}$	SCRUPLE = 20 minims = 0.0752 cu. in.	1.2322
$3.3815 \cdot 10^{-2}$	FLUID OUNCE = 8 drams = 1.805 cu. in.	$2.9573 \cdot 10$
$8.454 \cdot 10^{-3}$	GILL = 4 ounces = 7.220 cu. in.	$1.1829 \cdot 10^{2}$
$2.113 \cdot 10^{-3}$	PINT = 16 ounces = 28.88 cu. in.	$4.73179 \cdot 10^{2}$
$1.056 \cdot 10^{-3}$	QUART = 2 pints = 57.76 cu. in.	$9.46358 \cdot 10^{2}$
$2.641704673 \cdot 10^{-4}$	GALLON = 4 quarts = 0.1337 cu. ft. = 231 cu. in.	$3.78543 \cdot 10^{3}$
$8.387 \cdot 10^{-6}$	BARREL (wine) = 31½ gallons = 4.205 cu. ft.	$1.1924 \cdot 10^{5}$
$4.193 \cdot 10^{-6}$	HOGSHEAD = 63 gallons = 8.410 cu. ft.	$2.3848 \cdot 10^{5}$
$6.297 \cdot 10^{-6}$	BARREL (petroleum) = 42 gal. = 5.615 cu. ft.	$1.58984 \cdot 10^{5}$
$6.297 \cdot 10^{-6}$	TIERCE = 42 gal. = 5.615 cu. ft.	$1.5898 \cdot 10^{5}$
$3.148 \cdot 10^{-6}$	PUNCHEON = 84 gallons = 11.23 cu. ft.	$3.176 \cdot 10^{5}$

U. S. DRY MEASURE.

Cubic centimeter to A.	A.	A. to cubic centimeter.
$1.816 \cdot 10^{-3}$	PINT = 33.6 cu. in.	$5.506 \cdot 10^{2}$
$9.08 \cdot 10^{-4}$	QUART = 1.101 liters = 67.2 cu. in.	$1.10123 \cdot 10^{3}$
$2.27 \cdot 10^{-4}$	GALLON = 4.4049 liters = 268.8 cu. in.	$4.40492 \cdot 10^{3}$
$1.13 \cdot 10^{-4}$	PECK = 8.8098 liters = 537.6 cu. in.	$8.80984 \cdot 10^{3}$
$2.837742299 \cdot 10^{-5}$	BUSHEL = 9.31 U. S. Gal. = 2150.4 cu. in.	$3.523928 \cdot 10^{4}$
$9.418 \cdot 10^{-6}$	BARREL (flour) 196 lbs. = 88.904 kgm.=7056 cu. in.=4.08 cu. ft.	$1.06180 \cdot 10^{5}$
$8.849 \cdot 10^{-5}$	BARREL (cement) = 376 lbs. = 170.551 kgm. = 4.0 cu. ft.	$1.13 \cdot 10^{5}$

BRITISH LIQUID AND DRY MEASURE.

$1.693 \cdot 10$	MINIMS = about 1 drop = 0.00361 cu. in.	$5.9192 \cdot 10^{-2}$
$2.8219 \cdot 10^{-1}$	DRACHM = 60 minims = 0.2166 cu. in.	3.54958
$3.527 \cdot 10^{-2}$	OUNCE = 8 drachms = 1.733 cu. in.	$2.839661 \cdot 10$
$1.7608 \cdot 10^{-3}$	PINT = 20 ounces = 34.67 cu. in.	$5.6793 \cdot 10^{2}$
$8.804 \cdot 10^{-4}$	QUART = 1.136 liters = 69.34 cu. in.	$1.13586 \cdot 10^{3}$
$2.201 \cdot 10^{-4}$	GALLON = 4.543 liters = 277.274 cu. in.	$4.54345797 \cdot 10^{3}$
$1.1005 \cdot 10^{-4}$	PECK = 2 gallons = 554.4 cu. in.	$9.08692 \cdot 10^{3}$
$2.75121 \cdot 10^{-5}$	BUSHEL = 8 gallons = 2218.2 cu. in.	$3.63477 \cdot 10^{4}$
$6.87802 \cdot 10^{-6}$	COOMB = 4 bushels = 5.1347 cu. ft.	$1.453908 \cdot 10^{5}$
$3.43901 \cdot 10^{-6}$	QUARTER = 8 bushels = 10.269 cu. ft.	$2.907816 \cdot 10^{5}$

MISCELLANEOUS.

$5.085 \cdot 10^{-3}$	BOARD FOOT (1′ × 1′ × 1″) = 144 cu. in.	$1.96642 \cdot 10^{2}$
$2.760 \cdot 10^{-7}$	CORD (4′ × 4′ × 8′) = 128 cu. ft.	$3.6246 \cdot 10^{6}$
$8.1034 \cdot 10^{-10}$	ACRE FOOT = 362000 U. S. Gal. = 43560 cu. ft.	$1.2335 \cdot 10^{9}$
$8.88 \cdot 10^{-7}$	U. S. SHIPPING TON = 40 cu. ft.	$1.13268 \cdot 10^{6}$
$8.409 \cdot 10^{-7}$	1 BRITISH SHIPPING TON = 42 cu. ft.	$1.1893 \cdot 10^{6}$

U. S. liquid measure × 1.2003 = British liquid and dry of same denomination.
U. S. dry measure × 1.032 = British liquid and dry of same denomination.

WEIGHTS—CONVERSION FACTORS.

Grams to A.	A.	A. to grams.
1.000	GRAM (1 cc. water at 4°C.) = 15.432 grains	1.0000
$1.000 \cdot 10^{3}$	MILLIGRAM = 0.015432 grain	$1.0000 \cdot 10^{-3}$
$1.0000 \cdot 10^{-3}$	KILOGRAM = 2.679 T. lbs. = 2.204622341 Av. lbs.	$1.0000 \cdot 10^{3}$
$1.000 \cdot 10^{-5}$(a)	QUINTAL (100 kilograms) = 2.2046 cwt.	$1.0000 \cdot 10^{5}$
$1.000 \cdot 10^{-6}$	METRIC TON = 1.1023 ton (short) = 2204.6 lbs.	$1.0000 \cdot 10^{6}$
$1.5432 \cdot 10$	GRAIN (T. Ap. Av.) = 0.0020835 ounce (T.)	$6.4799 \cdot 10^{-2}$
$6.430 \cdot 10^{-1}$	PENNYWEIGHT (T.) = 24.0 grains	1.5552
$6.43 \cdot 10^{-2}$	CARET (T.) = 10.0 pwt.	$1.5552 \cdot 10$
$7.716 \cdot 10$	SCRUPLE (Ap.) = 20.0 grains	1.2960
$2.572 \cdot 10$	DRAM (Ap.) = 60.0 grains	3.8879
$3.215 \cdot 10^{-2}$	OUNCE (T.) = 1.09714 + oz. Av. = 480 grains	31.1035
$2.68 \cdot 10^{-3}$	POUND (T.) = 0.822857 lb. Av. = 12 oz. Troy	$3.732714662 \cdot 10^{2}$
$3.5273990 \cdot 10^{-2}$	OUNCE (Av.) = 0.911450 oz. T. = 437.5 grains	$2.834952673 \cdot 10$
$2.2046244 \cdot 10^{-3}$	POUND (Av.) = 1.2153 lbs. T. = 16 oz. Av. = 7000 grains	$4.535924277 \cdot 10^{2}$
$2.2046244 \cdot 10^{-5}$	HUNDRED WEIGHT (short) = 100 lbs.	$4.5359 \cdot 10^{4}$
$1.968414 \cdot 10^{-5}$	HUNDRED WEIGHT (long) = 112 lbs.	$5.0802 \cdot 10^{4}$
$1.1023122 \cdot 10^{-6}$	TON (U. S. short) = 2000 lbs.	$9.07184 \cdot 10^{5}$
$0.9845 \cdot 10^{-6}$	TON (British long) = 2240 lbs.	$1.016 \cdot 10^{6}$
$3.937 \cdot 10^{-5}$	STONE = 14 lbs.	$6.3503 \cdot 10^{3}$
$7.874 \cdot 10^{-5}$	QUARTER = 25 lbs.	$1.13368 \cdot 10^{4}$
4.8665	CARAT (precious stones) = 3.1713 grains	$2.055 \cdot 10^{-1}$
0.03429	ASSAY TON (metallurgists) = 1.0288 oz. Av. = 0.885188 oz. Troy	$2.91667 \cdot 10$

T. = Troy. Ap. = Apothecary. Av. = Avoirdupois

(a) $10^{-3} = 1/10^{3} = 1/1000 = 0.001$.

WORK CONVERSIONS.

	1. Erg.*	2. Joule.	3. Kilojoule.	4. Watt hour.	5. K. W. hour.	6. H. P. hour.
1. Erg.	1.0000	$10^{-7}(a)$	$1.000 \cdot 10^{-10}$	$2.778 \cdot 10^{-11}$	$2.778 \cdot 10^{-14}$	$3.725 \cdot 10^{-14}$
2. Joule.	10^{7}	1.0000	10^{-3}	$2.778 \cdot 10^{-4}$	$2.778 \cdot 10^{-7}$	$3.725 \cdot 10^{-7}$
3. Kilojoule.	10^{10}	10^{3}	1.0000	$2.778 \cdot 10^{-1}$	$2.778 \cdot 10^{-4}$	$3.725 \cdot 10^{-4}$
4. Watt hour.	$3.6 \cdot 10^{10}$	3600.000	3.600	1.000	$1.000 \cdot 10^{-3}$	$1.341 \cdot 10^{-3}$
5. Kilowatt hr.	$3.6 \cdot 10^{13}$	$3.6 \cdot 10^{6}$	3600.000	1000.000	1.000	1.3411128
6. Horse-power hr.	$2.684 \cdot 10^{13}$	$2.684 \cdot 10^{6}$	$2.684 \cdot 10^{3}$	745.6494	0.7456494	1.0000
7. Foot pound.	$1.3544 \cdot 10^{7}$	1.3544	$1.3544 \cdot 10^{-3}$	$3.762 \cdot 10^{-4}$	$3.762 \cdot 10^{-7}$	$5.046 \cdot 10^{7}$
8. Calorie (gm.)	$4.189 \cdot 10^{7}$	4.189	$4.189 \cdot 10^{-3}$	$1.163 \cdot 10^{-3}$	$1.163 \cdot 10^{-6}$	$1.560 \cdot 10^{-6}$
9. Brit. Thermal Units	$1.0553 \cdot 10^{10}$	1055.3	1.0553	$2.931 \cdot 10^{-1}$	$2.931 \cdot 10^{-4}$	$3.931 \cdot 10^{-4}$
10. Cu. ft. water fall— 1 ft. (4°C.)	8.463	84.63	0.08463	$2.351 \cdot 10^{-2}$	$2.351 \cdot 10^{-5}$	$3.153 \cdot 10^{-5}$
11. Kilogram-meter.	$9.8062 \cdot 10^{7}$	9.8062	$9.8062 \cdot 10^{-3}$	$2.724 \cdot 10^{-3}$	$2.724 \cdot 10^{-6}$	$3.653 \cdot 10^{-6}$

* The work done by one dyne acting through one centimeter is an erg.

(a) $10^{-7} = 1/10^{7} = 1/10{,}000{,}000 = 0.0000001$.

	7. Foot Lb.	8. Calorie (15° C.).	9. B. T. U.	10. Cu. ft. H_2O 1 ft.	11. Kgm. meter.
1. Erg.	$7.384 \cdot 10^{-8}$	$2.387 \cdot 10^{-8}$	$9.476 \cdot 10^{-11}$	$1.1812 \cdot 10^{-9}$	$1.0197 \cdot 10^{-8}$
2. Joule.	$7.384 \cdot 10^{-1}$	$2.387 \cdot 10^{-1}$	$9.476 \cdot 10^{-4}$	$1.1812 \cdot 10^{-2}$	$1.0197 \cdot 10^{-1}$
3. Kilojoule.	$7.384 \cdot 10^{2}$	$2.387 \cdot 10^{2}$	$9.476 \cdot 10^{-1}$	$1.1812 \cdot 10$	$1.0197 \cdot 10^{2}$
4. Watt hour.	$2.658 \cdot 10^{3}$	$8.594 \cdot 10^{2}$	3.4115	$4.2525 \cdot 10$	$3.671 \cdot 10^{2}$
5. K. W. hr.	$2.658 \cdot 10^{6}$	$8.594 \cdot 10^{5}$	$3.411 \cdot 10^{3}$	$4.2525 \cdot 10^{4}$	$3.671 \cdot 10^{5}$
6. H. P. hr.	$1.982 \cdot 10^{6}$	$6.407 \cdot 10^{5}$	$2.543 \cdot 10^{3}$	$3.170 \cdot 10^{4}$	$2.737 \cdot 10^{5}$
7. Ft. pound.	1.0000	$3.233 \cdot 10^{-1}$	$1.2835 \cdot 10^{-3}$	$1.600 \cdot 10^{-2}$	$1.381 \cdot 10^{-1}$
8. Calorie.	3.093	1.0000	$3.969 \cdot 10^{-3}$	$4.948 \cdot 10^{-2}$	$4.272 \cdot 10^{-1}$
9. B. T. U.	$7.794 \cdot 10^{2}$	$2.520 \cdot 10^{2}$	1.000	$1.247 \cdot 10$	$1.076 \cdot 10^{2}$
10. Cu.ft.H_2O 1 ft.	$6.250 \cdot 10$	$2.021 \cdot 10$	$8.022 \cdot 10^{-2}$	1.0000	8.630
11. Kgm.-meter.	7.241	2.341	$9.292 \cdot 10^{-3}$	$1.1582 \cdot 10^{-1}$	1.0000

PRESSURE CONVERSIONS.

	1. Cm. H_2O.	2. In H_2O.	3. Ft. H_2O.	4. Mm. Hg.	5. Cm. Hg.	6. In Hg.
1. Cm. water 4° C....	1.0000	0.3937	0.03281	0.7356	0.07356	0.02896
2. Inches of water....	2.540	1.0000	0.08333	1.8685	0.18685	0.07356
3. Feet of water......	30.48	12.00	1.0000	22.42	2.242	0.8826
4. Mm. of mercury....	1.3595	0.5353	0.4461	1.0000	0.10000	0.03937
5. Cm. of mercury....	13.595	5.353	4.461	10.00	1.0000	0.39370
6. In. of mercury......	34.54	13.595	1.1330	25.40	2.540	1.0000
7. Gm. per sq. cm......	1.000	0.3937	0.03281	0.7356	0.07356	0.02896
8. Kg. per sq. cm......	1000.0000	393.7	32.81	735.6	73.56	28.96
9. Oz. per sq. in......	4.394	1.7300	0.14416	3.232	0.3232	0.12725
10. Lbs. per sq. in......	70.32	27.68	2.307	5.171	0.5171	2.036
11. Oz. per sq. ft.......	0.03052	0.012012	0.0010012	0.02245	$2.245 \cdot 10^{-3}$	$8.836 \cdot 10^{-4}$
12. Lbs. per sq. ft......	0.4885	0.1923	0.01602	0.3591	0.03591	0.014137
13. Dynes per sq. cm....	$1.0197 \cdot 10^{-3}$	$4.0145 \cdot 10^{-4}$	$3.3455 \cdot 10^{-5}$	$7.500 \cdot 10^{-4}$	$7.500 \cdot 10^{-5}$	$2.952 \cdot 10^{-5}$
14. Atmospheres*.......	1033.29	406.806	33.9005	760.00	76.000	29.9212

Mercury at 0° C. Water at 4° C.

*Atmosphere is the pressure exerted by a column of mercury 76.0 cm. high at 0° C. at sea level and in a latitude of 45° upon the area of one square centimeter.

PRESSURE CONVERSIONS—Continued.

	7. Gms./cm²	8. Kgm./gm².	9. Oz./in².	10. Lbs./in².	11. Oz./ft².	12. Lbs./ft².	13. Dynes/cm².	14. Atmospheres.
1..........	1.0000	0.001000	0.2276	0.01422	32.77	2.048	980.62	$9.679 \cdot 10^{-4}$
2..........	2.540	0.002540	0.5780	0.036125	83.23	5.205	2492.0	0.002458
3..........	30.48	0.03048	6.937	0.4335	998.8	62.43	29890.0	0.02950
4..........	1.3595	0.0013595	0.3094	0.01934	44.56	2.785	1333.3	0.0013159
5..........	13.595	0.013595	3.094	0.1934	445.6	27.85	13333.0	0.013159
6..........	34.54	0.03454	7.860	0.4912	1131.7	70.73	33865.0	0.03342
7..........	1.000	0.001	0.2276	0.014223	32.770	2.048	980.62	$9.679 \cdot 10^{-4}$
8..........	1000.0	1.0000	227.6	14.223	32770.0	2048.0	980620.0	0.9679
9..........	4.394	$4.394 \cdot 10^{-3}$	1.0000	0.06250	144.0	9.000	4309.5	0.0042525
10..........	70.32	0.07032	16.000	1.0000	2304.2	144.00	68950.0	0.06805
11..........	0.03052	$3.052 \cdot 10^{-5}$	$6.946 \cdot 10^{-3}$	$4.340 \cdot 10^{-4}$	1.0000	0.06250	29.93	$2.9533 \cdot 10^{-5}$
12..........	0.4885	$4.885 \cdot 10^{-4}$	0.11112	0.006944	16.000	1.0000	478.9	$4.725 \cdot 10^{-4}$
13..........	$1.0197 \cdot 10^{-3}$	$1.019 \cdot 10^{-6}$	$2.3208 \cdot 10^{-4}$	$1.4504 \cdot 10^{-5}$	$3.3410 \cdot 10^{-2}$	$2.088 \cdot 10^{-3}$	1.0	$9.868 \cdot 10^{-7}$
14..........	1033.29	1.03329	235.152	14.697	33861.9	2116.37	1013295.0	1.00000

COMPARATIVE TEMPERATURE DEGREES.

	Degrees Absolute	Degrees Cent.	Degrees Fahr.	Degrees Reaumur.
Degrees Absolute	1.0	1.0	9/5	4/5
Degrees Centigrade	1.0	1.0	9/5	4/5
Degrees Fahrenheit	5/9	5/9	1.0	4/9
Degrees Reaumur	5/4	5/4	9/4	1.0

COMPARATIVE TEMPERATURE POINTS.

Absolute zero=—273° Centigrade=—459.4° Fahr.=—218.4° Reaum.
Freezing water = 0° C. = 273° A. = 32° F. = 0° R.
Boiling water = 100° C. = 373° A. = 212° F. = 80° R.

HEAT QUANTITY CONVERSION FACTORS.

One British Thermal Unit = 251.995 + calories (gm.) = 0.251995 + Cal. Large.
One gram calorie = 0.00396832 British Thermal Units.
One B. T. U. per pound = 5/9 calorie per gram.
One calorie per gram = 1.8 B. T. U. per pound.

TIME CONVERSION FACTORS.

One year = 365 days, 5 hours, 48 minutes, 48 seconds = 12 calendar months.
= 52.1693 + weeks = 8765.8133 + hrs. = 525948.8 minutes = 31556928 seconds.
One week 7 days = 168 hrs. = 10080 minutes = 604800 seconds.
One day = 24 hours = 1440 minutes = 86400 seconds.
One hour = 60 minutes = 3600 seconds.
One minute =60 seconds.

VELOCITY CONVERSION FACTORS.

	Mi./hr. 1.	Mi./da. 2.	Km./da. 3.	Ft./sec. 4.	Km./hr. 5.	M./sec. 6.
1. Miles per hour	1.0000	1.4667	1.6093	0.44704	24.00	38.62
2. Feet per second	0.6819	1.0000	1.0973	0.30480	16.37	26.33
3. Kilometers/hour	0.6214	0.9114	1.0000	0.2778	14.913	24.00
4. Meters per second	2.237	3.281	3.600	1.0000	53.69	86.40
5. Miles per day	0.04167	0.06112	0.06706	0.01863	1.0000	1.609
6. Kilometers/day	0.02589	0.03797	0.04167	0.01157	0.6214	1.0000

CONVERSION FACTORS FOR MONEY.

$ to A.	A.		A. to $.
1.000	Dollar (U. S.)		1.000
100.000	Cent (U. S.)		0.010
0.196	Guinea (English)	= 21 shillings	5.10972
0.2055	Pound Sterling (Sovereign)	= 20 shillings	4.8665
4.11	Shilling (s)	= 12 pence	0.24332
40.93	Penny (d)	= 4 farthings	0.02028
163.72	Farthing	= 1/4 penny	0.00507
0.822	Crown	= 5 shillings	1.21660
4.200	Mark (Germany)	= 100 pfennigs	0.238
420.0	Pfennig		0.00238
5.182	Franc (France)	= 100 centimes	0.193
518.2	Centime		0.00193

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